Review of literature is a necessary step for any scientific study as it helps in generalization of results. It serves the purpose that the work has previously been done in the area of research project in delineating the area of research that provides a theoretical/logical framework for the proposed study. It suggests the measures of operationalizing concept and helps in interpretation of findings of the study. A brief but pertinent direct indirect review of the previous researches is made herein as under:

**Yadav et al. (1992)** reported that oviposition and feeding preferences of *Spilosoma obliqua* [Walker] in the laboratory and in the field in Bihar, during 1984-85. Sesamum sp. and *Vigna mungo* acted as the main foci for the multiplication and spread of *S. obliqua* during June – August and August – October, respectively. The pest was also present on many other cultivated and wild plants at varying densities. Of 18 varieties of *V. mungo*, PLS 367 was the most preferred for oviposition, while oviposition was rare on Pant U 26, Pant U 4, Pant U 30 and T 9. The variety Krishna had the greatest number of larvae/plant, while Pant U-19 had the lowest number. Damage was least (37.5% leaves) on G 31, being 90-100% on other varieties.

**Prasuna et al. (1994)** revealed that Electroantennogram (EAG) responses of male and female *Diacrisia obliqua* [*Spilarctia obliqua*] were recorded for 10 general plant volatiles: propanol, butanol, pentanol, heptanol, beta-ionone, alpha-pinene, geraniol, citral, linalool, trans-2-hexenal and hexane-1-ol. Both the sexes of *S. obliqua* were responsive to the volatiles tested. A high degree of uniformity in responsiveness between the sexes was observed for most of the compounds. Only 3 out of 10 compounds screened caused almost saturated threshold responses at the doses (50, 100 and 200 micro ℓ) tested and little difference in EAG amplitude was recorded for
the different sexes. The antennal olfactory receptors of *S. obliqua* were sensitively tuned to the perception of the general plant volatiles.

**Arora et al. (1996)** reported that field studies in groundnuts in Ludhiana, Punjab, showed that nuclear polyhedrosis virus at 250 LE ha\(^{-1}\) was effective against *Spilosoma obliqua*, but a period of at least 5 days was required to obtain sufficient mortality.

**Nath and Singh (1996)** reported that *Spilosoma obliqua* on groundnuts showed the average incubation, larval, prepupal and pupal periods as 5.60, 24.72, 1.76 and 11.46 days respectively. The average pre-oviposition, oviposition and post-oviposition periods were 2.40, 2.88 and 4.00 days, respectively. The life cycle was completed in 53.06 days. Out of 17 insecticides tested, phosphamidon, endosulfan and malathion were the most effective against *S. obliqua*. A combination of preventive + curative applications was significantly superior to preventive or curative applications alone.

**Jaglan and Sircar (1997)** determined the efficacy of laboratory emulsion formulations of cypermethrin, deltamethrin, fenvalerate and fenpropathrin against third-instar larvae of *Spodoptera litura* and third-instar larvae of *Spilosoma obliqua* [*Spilarctia obliqua*] and compared with the efficacy of these insecticides in proprietary products. The laboratory prepared cypermethrin formulation was less effective against *S. obliqua* than proprietary cypermethrin, whereas the reverse was true for the remaining synthetic pyrethroids. The laboratory prepared formulation of fenvalerate, deltamethrin, fenpropathrin and cypermethrin was 1.72, 1.48, 1.12 and 0.16 times more effective against *S. obliqua* than the corresponding proprietary products. Laboratory prepared emulsions of cypermethrin, fenvalerate, deltamethrin and fenpropathrin were 27.17, 51.62, 2.36 and 7.89 times and proprietary formulations
were 0.36, 12.32, 0.93 and 5.87 times more effective against *S. litura* than *S. obliqua*, respectively.

**Thakur et al. (1997)** carried out field studies in Himachal Pradesh, in the kharif season of 1993, hand picking and removal of sesame leaves containing egg masses, and 1st- and 2nd-instar larvae of *Spilosoma obliqua* [*Spilarctia obliqua*] on 14 August, followed by hand removal of 4th- and 5th-instar larvae 2 weeks later. The first removal resulted in complete elimination of larvae compared to pre-treatment larval counts, but the 2nd removal failed to give complete elimination, as up to 26.7% of the population was observed after 48 h. This method was more than 3-fold cheaper than conventional insecticidal control.

**Gupta et al. (1999)** studied the effect of seven commercial neem products (Margocide - 0.15% azadirachtin, Neem Gold - 0.15% azadirachtin, Neemark - 0.03% azadirachtin, Achook - 0.03% azadiradione, nimbocinol and epinimbocinol, Nimbicidine - 0.03% azadirachtin, Neemta 2100-0.15% azadirachtin and Field Marshal - 0.3% azadirachtin) at 10 000, 1000 and 100 ppm with water or alcohol extracts of neem bark, neem leaves (dried) or neem cake (4 and 2%) on the growth of *Beauveria bassiana*. Commercial formulations exhibited varying effects on the growth of *B. bassiana* ranging from inhibitory or neutral to stimulatory. It was concluded that Achook, Field Marshal, Margocide, Nimbicidine, neem cake and alcohol or water extracts of neem leaves can be used in combination with *B. bassiana* as part of an IPM strategy against selected pest species.

**Gahukar (2000)** concluded that products derived from leaves and kernels of neem (*Azadirachta indica* A. Jussieu) are becoming popular in plant protection programmes for cotton, mainly because synthetic pesticides have several undesirable effects. Neem derived pesticides have been found to be effective and economic in
controlling major cotton pests. Neem products act both as systemic and as contact poisons and their effects are antifeedant, toxicological, repellent, sterility inducing or insect growth inhibiting. Furthermore, neem products appear to be environmentally safe and IPM compatible and have the potential to be adopted on a broad scale, together with other measures, to provide a low cost management strategy.

Hirose et al. (2001) revealed that three bio fertilizers (EM-4, Multibion and Supermagro) and neem oil against the entomopathogenic fungi, *Metarhizium anisopliae* and *Beauveria bassiana*. These products were mixed with the medium upon which the fungi were inoculated, and germination, vegetative growth and conidiogenesis were assessed. Supermagro and EM-4 were less toxic to the entomopathogenic fungi than Multibion, which exhibited strong activity against *M. anisopliae* and reduced the germination, colony diameter and conidiogenesis of the said fungus by 37.74, 30.26 and 42.62%, respectively. Neem oil showed strong activity against *B. bassiana* and reduced the germination, colony diameter and conidiogenesis of the said fungus by 45.27, 36.62 and 84.93%, respectively.

Karmarkar and Bhole (2001) determine the efficacy and persistent toxicity of some neem products (1 and 2% neem oil); 1 and 2% Nimbecidine; 1 and 2% Neemark; 1 and 2% Nimbitor against adults of *Epilachna dodecastigma*. The treatments with 2% neem oil (100%), 2% Nimbecidine, 2% Neemark at 90.69 and 71.90%, respectively, was the most effective at 48 and 72 hours post-treatment. The treatment with 0.05% endosulfan recorded the highest mean percent protection (up to 8 days) followed by 2% Neemark and 2% neem oil (up to 6 days).

Dev Narayan (2004) reported that last instar larvae of *S. obliqua* on leaves of til (*Sesamum indicum*) treated with diflubenzuron (Dimilin 25 WP) at different concentrations (0.015, 0.03, 0.06, 0.125, 0.25, 0.5 and 1.0%). This resulted in various
morphogenetic deformities and weight losses among the larvae. The overall effect of the test compound was assessed on the basis of inhibition of adult emergence, which was more than 50% even at 0.06% concentration. Therefore, diflubenzuron may safely be included in the pest management programme of *S. obliqua*.

Singh and Srivastava (2004) carried out laboratory and field experiments during 1999 and 2000 in Chaubattia, Uttaranchal, to determine the efficacy of neem-based formulations against defoliating hairy caterpillar, *Spilosomarhodophila* [*Lemyrarhodophila*], infesting walnut trees. The treatments comprised: 0.5 and 1.0% Neemark 0.03% EC; 0.05 and 1.0% Neemaring 0.15% EC; 0.5 and 1.0% Nimbecidine 0.03% EC; 0.05 and 1.0% Godrej Achook 0.15% EC; 0.5 and 1.0% Vanguard-L 300 ppm; and 0.05% dichlorvos 76 EC. Neemarin at 0.5 and 1.0% gave the highest efficacy against *S. rhodophila* (00.00 cm² mean damaged leaf area) under both laboratory and field conditions.

Mandal and Ray (2005) studied Bihar hairy caterpillar (BHC; *Spilosomaobliqua* [*Spilarctiaobliqua*]) infestation on sunflower during 2003-05 in West Bengal. Data were collected at an interval of 7 days. Nature of damage was recorded during each survey trip. The BHC were found to damage the plants. They feed mainly on leaves. The severe attack by full-grown larvae caused complete defoliation of the plants. The maximum damage was recorded in February and March. The female moth after mating with male layed eggs on the underside of the leaves. The spherical eggs were laid in clusters and were light green in colour. After incubation period of 1-2 weeks, the eggs were hatched into tiny larvae. The larval period lasted for 4-5 weeks. Full-grown larvae measured 4 – 4.5 cm in length, profusely covered with long greyish hairs. After attainment of full growth, larva spinned a loose silken cocoon, within which pupation took place in plant debris or in
the soil. The pupal period lasted for 1-2 weeks and then adult moth emerged. The total life cycle from egg to adult took 6-9 weeks. The management (cultural, mechanical, biological and chemical) of BHC is briefly discussed.

**Veenakumari* et al. (2005)** studied the efficacy of nuclear polyhedrosis virus (NPV) against the red hairy caterpillar (*Amsactaalbistriga*) in groundnut cv. TMV 2. The results showed that *A. albistriga* NPV was as effective as chlorpyrifos applied at 20 g a.i ha\(^{-1}\) against the red hairy caterpillar. For an environmentally friendly approach, *A. albistriga* NPV can be used as an effective component of integrated pest management packages for the control of red hairy caterpillars in the endemic areas of Karnataka.

**Biswa** (2006) reported that incidence and management of hairy caterpillar, *Spilarctiaobliqua* (Walker) on sesame. The pest appeared in the sesame crop in the fourth week of April at the flowering stage at 45-55 days after sowing (DAS) and remained up to third week of June at the pod maturity stage at 90-95 DAS. The peak populations of I (4.00 – 4.50 larvae per plant) and their severe infestation (100% plant) were recorded in the fourth week of May, at the pod filling stage at 60-70 DAS of the crop. The yield reduction of sesame caused by I in the treatments 1 spray, 2 sprays, 3 sprays, and 4 spray frequencies with Diazinon 60 EC @ 2 ml/litre were calculated 25.00, 30.86, 35.24 and 37.23 percent, respectively. One spray of Diazinon 60 EC applied at the pod formation stage at 50-55 DAS gave the highest benefit cost ratio (4.20).

**Dhingraet al. (2006)** reported that Neem Oil micro-emulsion showed a significantly superior bio-efficacy than its macro-emulsion against *Spodopteraliture*, *Spilarctiaobliqua* and *Euproctislunata*. The IC\(_{50}\) values for inhibiting adult emergence in case of micro- and macro-emulsions were 0.09 and 0.14% against *S. litura*; 0.07
and 0.10% against *S. obliqua* and 0.01 and 0.22% against *E. lunata*. The relative effectiveness of micro- to macro- was 1.5: 1.0 against *S. litura*; 1.4: 1.0 against *S. obliqua* and 3.9: 1 against *E. lunata*.

**Mandal et al. (2006)** studied during two consecutive summer seasons (2000 and 2001) in Bihar, India to evaluate neem-based integrated management approaches for controlling insect pests (*Amrascabiguttula* and *Eariasvittella*) on okra cv. PusaSawani. The treatments included soil application of neem cake at 200 kg/ha with foliar applications of neem seed kernel extract (NSKE 5%), neem oil 3%, Amrutguard 0.5%, neem leaf decoction at 0.5 kg, chlorpyrifos 20 EC at 0.5 kg, endosulfan 35 EC at 0.5 kg and recommended insecticide, monocrotophos 36 SL at 0.4 kg. The integrated treatments were effective against the pests and were superior to the recommended insecticide. Neem cake + endosulfan and chlorpyrifos were more effective than the other integrated treatments in increasing yield and controlling pests. The maximum cost:benefit ratio (1:5.16) was obtained with neem cake + endosulfan, followed by neem cake + chlorpyrifos (1:4.37), monocrotophos (1:4.24) and neem cake + Amrutguard (1:3.55), while the minimum (1:2.01) was obtained from neem cake + neem oil.

**Purwar and Sachan (2006)** revealed that the effect of *Beauveriabassiana* (Balsamo) Vuillemin and *Metarhiziumanisopliae* (Metschnikoff) Sorokin on the toxicity of endosulfan, imidacloprid, lufenuron, diflubenzuron, dimethoate and oxydemeton methyl against 10-11 days old larvae of *Spilarctiaobliqua* (Walker). They concluded that a number of fungal parasites infect a wide range of insects and cause epizootics from time to time. For some products the combination treatments showed higher dose mortality response than the sole treatment of fungal conidia or the insecticide. The combination of insecticides with *B. bassiana* showed 1.26 – 35.8 fold
increase in toxicity of insecticides over sole treatment, while the increase was 1.05 – 72.0 fold in case of *M. anisopliae*. Imidacloprid 17.8 SL and oxydemeton methyl 25EC may be used in combination with these fungi for management of *S. obliqua*.

**Varatharajan et al. (2006)** reported that *Spilarctia obliqua* nucleopolyhedrosis virus (SoNPV) was found effective against *S. Obliqua* (Walker) as well as *Porthesia xanthorrhoea* Kollar. LC$_{50}$ concentration of *S. obliqua* SoNPV against *S. obliqua* and *P. xanthorrhoea* was 2.5 x 10$^4$ and 3.7 x 10$^4$ POBs/ml, respectively. LT$_{50}$ of SoNPV against *S. obliqua* was 5.73 days, while it was 6.98 days for *P. xanthorrhoea*. Cross infectivity of SoNPV against *P. xanthorrhoea* and ease of its mass production may make it an ideal biopesticide.

**Banuet et al. (2007)** compared some non-chemical approaches with chemical pesticides for the management of jute yellow mite and jute hairy caterpillar in greenhouse of BJRI, Dhaka and in the field of Jute Agricultural Experimental Station (JAES), Manikganj. Double spray of Green Neem leaf extract @ 1:20 and Dry Neem leaf @ 1:50 found effective and gave 74.63% and 70.83% mortality after 72 hrs. of treatment on potted plants. Green Neem leaf extract (Double spray) gave 67.70% reduction of infestation at the 7th day after spray and fibre yield 880.1 kg/acre with 19.9% gain over control. Dry Neem leaf extract (Double spray) gave 72.20% reduction of infestation at the 7th day after spray and fibre yield 892.1 kg/acre with 35.9% gain over control. In average 92 kg fibre yield/acre was increased over control by hand picking methods of jute hairy caterpillar. Neem leaf extracts and Hand picking method found to be effective, easiest, economic and environmental friendly alternative control measures of chemical pesticides for jute pests.

**Gupta and Bhattacharya (2007)** reported that toxicity of four naturalyte compounds, namely commercially available botanical extract of *Derris*
indica (Pongamiaglabra [Pongamiapinnata]), Karanzin (Derisom 2 EC); a proinsecticide cartap hydrochloride (Sanvax 50 SP); a growth regulator spinosad (Tracer), produced by fermentation of a rare bacterium, Sacharopolysporaspinosa', and a semi-synthetic second generation avermectin insecticide emamectin benzoate (Proclaim 5G) compared with four conventional insecticides of different chemical groups (endosulfan, chlorpyrifos, cypermethrin and alphamethrin) against first and fourth instar larvae of S. obliqua as they have gregarious and solitary feeding habits, respectively, at these two different age groups. Based on relative toxicity, alphamethrin was most effective against both steps of the test insect at all the three exposure periods.

Islam et al. (2007) revealed that effect of neem products on food consumption, growth and development of jute hairy caterpillar, in the laboratory of the Department of Entomology, Jute Research Institute, Dhaka, during the period from April to August 2005. The room temperature was maintained at 270 ± 10°C and light and darkness ratio was an average 13: 11. Fourth instar larvae of jute hairy caterpillar were exposed to jute leaves treated with neem oil at 0.5% concentration both for 48 hours and continuously throughout the larval period (continuous treatment). Neem oil reduced the food consumption of jute hairy caterpillar larvae and inhibited growth and development of larvae as compared to control. The effects were more pronounced in continuous treatment. Neem oil prolonged the duration of larval period, reduced size of the larvae and produced hairless larvae and abnormal pupae. Adults developed from treated larvae were malformed with crippled wings.

Mohan et al. (2007) conducted a study in which a sample of 30 isolates of B. bassiana from culture collections was screened for compatibility with a commercial formulation of neem oil (Margoside Reg.) at the field recommended dose (0.3%, v/v).
Compatibility was tested in vitro through germination and growth assays. In all isolates, conidial germination was delayed but not significantly decreased by neem. In the growth assays, 23 isolates were found compatible with neem. In the neem sensitive isolates, growth was decreased but not totally inhibited. The effect of combined treatment with \textit{B. bassiana} and neem in comparison to single treatments with either of them on \textit{Spodopteraliturata} was tested in laboratory bioassays. The combined treatment was found to have synergistic effect on insect mortality when a \textit{B. bassiana} isolate compatible with neem was used, while, with an isolate sensitive to neem, an antagonistic effect was observed.

\textbf{Ambethgar (2008)} studied twelve commonly used synthetic insecticides and three neem formulations in rice pest management at three different concentrations viz., 10X, 1X and 0.1X (where X=recommended field rate) with the entomopathogenic \textit{Beauveriabassiana} (Bals) Vuill isolate: BbCm KKL 1100 under in vitro using the agar plate poisoned food technique for predicting their combined performance against rice leaf folder, \textit{Cnaphalocrocismedinalis} in a field situation. The sensitivity of \textit{B. bassiana} in terms of radial growth extension was quantified during the whole test period of 14 days at 26 ± 2°C under laboratory condition. Generally, all of the insecticides/neem formulations tested had adverse effects on the mycelial growth either partially or completely. At the 10X rate, all the insecticides pronounced fungicidal effect on \textit{B. bassiana} exhibiting total (100%) inhibition of mycelial growth, while the neem formulations strongly inhibited the fungus growth impairing 70-86% biomass production. At the 1X rate, carbaryl and carbofuron showed total (100%) inhibition, but all other insecticides and neem formulations showed a fungistatic effect with 41.48-75.5% mycelia inhibition observed. The 0.1X rate of insecticides showed a varying degree of fungistatic effects, but chlorpyriphos(27.33%) and NSKE (22.2%)
exhibited slightly harmful effects and are probably compatible with *B. bassiana* in the field. This is not the case with rest of the insecticide formulations, which are moderate to strongly antagonistic to the fungus.

**Gupta and Bhattacharya (2008)** studied the lethal and sublethal effects of three post-emergence herbicides, 2,4-D ethyl ester (Weedkill 80WP), imazethapyr (Pursuit 10EC) and quizalofop ethyl (Tergasuper 5EC) fortified with artificial diets larvae of *Spilarctia obliqua* Walker (Lepidoptera: Arctiidae). Quizalofop ethyl and imazethapyr caused significant reduction of pest survival at almost all levels; however, 2,4-D ethyl ester was nontoxic. Interestingly, LC50 data (0.230 and 0.855% for quizalofop ethyl and imazethapyr, respectively) obtained from probit analysis were almost equal to labeled doses (x) of quizalofop ethyl (x=0.16%) and imazethapyr (x=0.625%), which shows the high toxicity of these compounds against *S. obliqua* larvae. Among the three herbicides, imazethapyr caused sublethal effects on this pest, increasing the larval period at almost all concentrations tested in the artificial diet. Considering the markedly significant effect of quizalofop ethyl on pest survivorship with no sublethal effect, we suggest incorporating it into the integrated pest management module for *S. obliqua* in legumes or oilseed crops with other biorational insecticides. Based on toxicity, imazethapyr can be a potential candidate for integrated management of *S. obliqua*. However, because of its sublethal effects, we advocate caution while using it in the presence of pest infestations.

**Kulkarni and Adsule (2008)** reported that thrips *Rhipiphorothrips cruentatus* and *Scirtothrips dorsalis* cause considerable loss in grapes mainly by deteriorating the quality by scab formation on berries. Several chemicals used to contain this pest could end up residue problems at harvest. There is a need to evaluate safer alternatives like neem formulations and biopesticides as there
was limited scope for commercial release and their availability of parasites and predators for this pest in grape vineyards. Two commonly used biopesticides *Beauveria bassiana* (Powder formulation) @ 5 g/l and *Verticillium lecanii* (Both liquid and powder formulation) @ 5 ml and 5 g/l respectively, popularly used neem formulation of different strength namely 0.3% (3000 ppm), 1% (10,000 ppm) and 5% (50,000 ppm) @ 5, 2.5 and 1 ml/l respectively and standard insecticide Thiamethoxam 25 WG were tested for their bio-efficacy in reducing thrips population during flowering period i.e. November-December of 2004 and 2005 at NRC for Grapes, Pune on Tas-A-Ganesh variety trained to ‘Y’ system. It has been observed that both *Beauveria bassiana* and *Verticillium lecanii* were significantly effective in reducing thrips population and former one was more effective than latter in reducing thrips population. Different concentrations of neem were equally effective in reducing thrips population but they were significantly superior over biopesticides tested. However, Thiamethoxam 25 WG treated plots recorded lowest number of thrips than all other treatments and similar trend was reflected in obtaining fruit yield.

**Waqas et al. (2008)** studied in laboratory bioassay using 2nd and 4th instar of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) field on chickpea, *Cicer arietinum* (L.), to determine the efficacy of neem (*Azadirachta indica* A. Juss) products. Neem leaf extract, neem seed kernel extract and neem oil were used alone and in combinations at the concentrations of 5% of each treatment. There was a significant difference in the mortality and all the treatments were effective. The 2nd instar larvae were more susceptible to the neem products and after 72 hours the maximum mortality (50%) was observed in the treatment where the neem leaf extract + neem seed kernel oil was used. This treatment gave 40% of the mortality of 4th instar larvae of *H. armigera* at the same exposure interval.
Ambethgaret *et al.* (2009) revealed that compatibility of *Beauveriabassiana* (Balsamo) Vuillemin (isolate BbCm KKL 1100) with twelve insecticides and three neem formulations on agar plate to develop suitable combinations 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 concentrations (10X, 1X and 0.1X, 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 10X concentration. At 1X concentration, carbofuran caused total inhibition, but all other insecticides caused 47.4-75.5% inhibition. However, at 0.1X concentration, only neem seed kernel extract, chlorpyriphos and dimethoate exhibited 22.2%, 27.3% and 32.6% mycelial inhibition, respectively, and these could be used with *B. bassiana* in the field condition.

Araujo *et al.* (2009) reported that efficiency of the entomopathogenic fungi *Metarhiziumanisopliae* and *Beauveriabassiana* to control the aphid *Lipaphiserysimi* (Kalt.) (Hemiptera: Aphididae) in kale *Brassica oleracea* varacephala D.C., as well as their compatibility with a neem oil formulation (NeemsetoReg.). Ten isolates of both fungi were tested and the most pathogenic ones were *B. bassiana* CG001 and *M. anisopliae* CG30 with 90% and 4.4 days, and 64% and 3.8 days of mortality and median lethal time, respectively. Bioassays with neem at concentrations of 0.5, 1.0 and 2.0% were done either by leaf discs dipping or spraying the aphids on the leaf discs. The neem spraying treatment at 2.0% provided 90% mortality. The use of *B. bassiana* isolate CG001 or *M. anisopliae* isolate CG30 with neem at 0.125, 0.25, and 0.5%, demonstrated that these isolates could have their spore viability or colony growth affected when exposed to neem concentrations higher than 0.25%. In absolute
values, the isolates *B. bassiana* CG001 and *M. anisopliae* CG30 are the most virulent to *L. erysimi*, and could be utilized in the management of this pest.

**Gupta et al. (2009)** studied the non-target effects of three plant growth stimulants (gibberellic acid, Siapton and triacontanol) and two plant growth retardants (chlormequat chloride and mepiquat chloride) on the survivorship and developmental parameters of *Spilarctia obliqua* Walker (Lepidoptera: Arctiidae). For each compound, various concentrations (0.125x, 0.25x, 0.5x, x, 2x and 4x; x = labeled dose) bracketing the labeled dose were prepared by serial dilution and mixed with an artificial diet for the insect. Gibberellic acid caused an increase in the larval period at x-4x, but no marked difference was observed in the pupal period or in larval survival at any concentration. Siapton induced a significant increase in larval period at the two highest doses but caused significant reduction in pest survival at x-4x. Interestingly, triacontanol induced a significant reduction in pest survivorship at almost all doses. The LC50 for triacontanol was 0.206% and LT50 was 266.5 hours at the labeled dose. However, triacontanol did not cause any significant difference in larval or pupal periods at any dose tested. Chlormequat chloride and mepiquat chloride caused significant reduction of larval survivorship at concentrations higher than the labeled doses, and no effect on the larval period. Intriguingly, a significant reduction in pupal period was observed with chlormequat chloride at x and 0.25x. Based on the marked effect of triacontanol on pest survivorship, this study suggests incorporating triacontanol in integrated pest management modules for *S. obliqua*. Caution in the use of gibberellic acid and Siapton for pest infestations is also indicated.

**Amuthaet al. (2010)** studied the compatibility of *Beauveriabassiana* in the laboratory condition with twelve commonly used insecticides for cotton pest management by poisoned food technique. The results were expressed as percentage of
growth inhibition of*B. bassiana* colony on insecticide treated medium. Among the insecticides tested for their compatibility, only chlorpyriphos 20 EC was rated as relatively less toxic to*B. bassiana*, while, spinosad (45% SC), econeem (1%), quinalphos (25 EC), acetamprid (20%), endosulfan (35 EC) and thiodicarb (75 WP) were slightly toxic. Imidacloprid (17.80% SL) and triazophos (40 EC) were moderately toxic and profenofos (50 EC), indoxacarb (14.5% EC) and methyldemeton were highly toxic. Results of the present study suggested that except profenophos, indoxacarb and methyldemeton, the rest of the insecticides tested can be safely used along with the entomopathogenic fungi*B. bassiana*.

Islam* et al.* (2010) conducted a study on the compatibility of the entomopathogenic fungus* Beauveria bassiana* (Balsamo) Vuillemin (Ascomycota: Hypocreales) with neem was against sweetpotato whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), on eggplant. Initially, three concentrations of*B. bassiana* (106, 107, and 108 conidia ml⁻¹) and three concentrations of neem (0.25, 0.5, and 1.0%) were used as individual treatments against*B. tabaci*. The highest concentration of*B. bassiana* yielded the highest*B. tabaci* egg (25.2%) and nymph mortalities (73.0%), but this was not significantly different from the mortalities caused by the 107 conidia ml⁻¹ suspension. Similarly, the highest concentration of neem yielded the highest egg (27.3%) and nymph mortalities (75.5%), which was also not significantly different from the 0.5% suspension. Therefore, 0.5% neem was used along with 107*B. bassiana* conidia ml⁻¹ suspension as an integrated pest management program against*B. tabaci*. The combination of*B. bassiana* and neem yielded the highest*B. tabaci* egg (29.5%) and nymph mortalities (97.2%), and the lowest LT50 (2.08 day) value. Moreover, an integrated combination of*B. bassiana* with neem caused 27.6 and 20.5% more nymphal mortality than individual treatments of*B. bassiana*.
bassiana and neem, respectively, 7 days post-application. Thus, a combined application of an entomopathogenic fungus and a botanical insecticide may benefit from both, and it has proven effective for the control of B. tabaci on eggplant.

Khan et al. (2010) reported the efficacy of chlorpyrifos (0.02 or 0.04%), Dipel (Bacillus thuringiensisserovar Kurstaki) (0.075 or 0.03%), and chlorpyrifos + Dipel (0.04 + 0.075, 0.02 + 0.075, 0.04 + 0.03 or 0.02 + 0.03%) against S. obliqua on castor beans. At one day after treatment (DAT), larval mortality was 68.3 and 33.3% for chlorpyrifos at 0.04 or 0.02%, respectively; 80.0% for chlorpyrifos + Dipel at 0.04 + 0.075%; 73.3% for chlorpyrifos + Dipel at 0.04% + 0.030%; and 66.6% for chlorpyrifos + Dipel at 0.02 + 0.075%. At 4 DAT, larval mortality reached 80.0 and 43.3% with chlorpyrifos at 0.04 and 0.02%, respectively; 90.0% with chlorpyrifos + Dipel at 0.04 + 0.075%; 83.3% with chlorpyrifos + Dipel at 0.04 and 0.03%; and 55.0 and 46.6% with Dipel at 0.075 and 0.030%, respectively. At 8 DAT, larval mortality was 88.3 and 58.3% for chlorpyrifos at 0.04 and 0.02%, respectively; 75.0 and 61.6% for Dipel at 0.075 and 0.030%, respectively; and 93.3% for chlorpyrifos + Dipel at 0.04 + 0.075%.

Rakesh and Shamshad (2010) determined the efficacy of different botanical insecticides for the management of Spilarctia obliqua in sesame. The treatments comprised 5% NSKE, 2% Neem leaf extract (NLE), 5% Karanj seed kernel extract (Pongamiapinnata; KSKE), 2% Mahuwa (Madhucalongifolia) oil, 2% Neem oil, 0.15% Nimbecidine, 0.07% Endosulfan 35 EC and control. The number of larvae present on 5 randomly selected plants in each plot were recorded before treatment and at 3, 7 and 10 days after treatment. All treatments were superior compared to the control. Endosulfan 35 EC at 0.07% had the best performance, followed by 5% NSKE, 2% NLE, 0.15% Nimbecidine, 2% Neem oil, 2% Mahuwa oil and 5% KSKE,
with 23.0, 17.6, 16.4, 15.3, 14.3 and 11.5% larval population reduction, respectively. All the treatments were also effective at 7 and 10 days after treatment.

**Fajardo and Canal (2011)** revealed that fifteen strains from entomopathogenic *Beauveria bassiana* and *Metarhizium anisopliae* fungi on one day-old adults of *Anastrepha obliqua* fruit fly. Tests were carried out for selecting the most virulent strains and the effectiveness of their use on young adult when the entomopathogen were applied before emergence were studied too. A screening with a 1 x 107 conidia/mL concentration was used for selecting the three most pathogenic isolates, two from *Beauveria* and one from *Metarhizium*, having 77, 71 and 66% mortality. The LC50 for these isolates were 2.38 x 106, 1.81 x 106 and 9.94 x 106 conidia/mL, respectively, and a respective LT50 were 48.12, 56 and 42.75 hours. No significant differences were found between females and males mortality. LC90 spraying of selected strains on fly pupation medium led to 34 – 48% mortality at 120 hours. Entomopathogenic fungi could be used for *A. obliqua* biological control and also it can be used easily spraying towards young adults under tree canopies in the integrated pest management programs.

**Gupta and Yadav (2011)** worked with relative contact toxicity of 17 conventional and new insecticides against two damaging stages of *Spilosoma obliqua* Walker larva. The descending order of relative toxicity for 3 – 4 days old larvae was: lambda–cyhalothrin>deltamethrin>alphamethrin>chlorpyriphos>cypermethrin>fenvalerate>quinalphos>Prokill>prophenophos>dichlorvos>monocrotophos>methomyl>triazophos>phenthoate>endosulphan>C-505>dimethoate. Order of toxicity for 15 – 16 days old larvae was: deltamethrin> l – cyhalothrin>cypermethrin>alphamethrin>fenvalerate>chlorpyriphos>quinalphos>Pro
kill>dichlorvos>triophos>methomyl>prophenophos>monocrotophos>endosulphan>phenothoate>C-505>dimethoate. On the basis of present investigation, it was suggested that judicious use of synthetic pyrethroids (deltamethrin, l-cyhalothrin, cypermethrin, alphamethrin and fenvalerate) and combination product Prokill (profenophos + cypermethrin) could be incorporated in the integrated pest management programme of *S. obliqua* as these are potential and comparatively safer alternative to conventional insecticides. Furthermore, relative toxicity of these insecticides was more than organophosphate compounds tested against the target pest.

*Islam et al. (2011)* reported that in a previous experiment, sweetpotato whitefly was found to be difficult to control with either neem or *Beauveria bassiana* alone. This earlier research also reported that the combined application of neem and *B. bassiana* increased mortality of whitefly nymphs when both of these products were applied to eggplant foliage; but a higher concentration of neem (more than 0.5%) was slightly toxic for young eggplant. Therefore, the present research was undertaken with these two products in which neem was applied as soil drench and *B. bassiana* was applied to foliage. Three concentrations of neem – 0.25, 0.5 and 1.0%; and three concentrations of *B. bassiana* – 10^6, 10^7 and 10^8 conidia/ml were used to investigate the combined efficacy against sweet potato whitefly, *Bemisia tabaci*. The results demonstrated that maximum nymph mortality (92.3%) occurred when 1.0% neem was combined with 10^8 conidia/ml of *B. bassiana*. The highest (14.3) mortality ratio (N/Bb; mortality caused by neem/mortality caused by *B. bassiana*) occurred when 1.0% neem was combined with 10^6 conidia/ml of *B. bassiana*; and the lowest mortality ratio (5.7) occurred when 0.25% neem was combined with 10^8 conidia/ml of *B. bassiana*. The results showed that neem was compatible with *B. bassiana*; and suggest that soil application of neem along with foliar application of *B. bassiana* might
be useful for the control of *B. tabaci*.

**Sudharani and Rath (2011)** reported that efficacy of neem-based products, either alone or in alternation with *Beauveriabassiana* and endosulfan against *Helicoverpa armigera* infesting tomato. The treatments were applied starting from the fruit development stage (first spray) until harvest at an interval of 10 days. Neem oil (multineem) was applied at 4 ml/litre. Neem cake slurry suspension (NCSS) was prepared by soaking 1.0 kg neem cake powder in 10 litres of water for 72 h and the supernatant was filtered and sprayed. A total of 3 sprays were made and larval population count was recorded at 7 and 10 days after each spray. Results showed that the best treatment that recorded the best *H. armigera* control and highest tomato yield was the use of endosulfan. Although endosulfan sole treatment was the best treatment with respect to larval mortality with higher fruit yield, yet, keeping in view the ecological safety, the alternate application of neem oil with endosulfan treatment and sole application of neem oil treatment was recommended as the best for tomato fruit borer management.

**Chandelet et al. (2012)** studied on use of eco-friendly naturally occurring plant products in the management of the mustard aphid, *Lipaphis erysimi* Kaltenbach (*Hemiptera*Aphididae) under laboratory conditions. The results revealed that the nymphs and adults mortality of mustard aphid varied significantly with three different concentrations (0.5, 1.0 and 2.0%) of five plant products. The mortality was high with seed kernel extracts of neem, *Azadirachta indica* killed nymphs and adults of *L. erysimi* (70.82 %) followed by leaves extracts of lagundi, *Vitex negundo* Linn. (69.40 %), leaves extract of *Parthenium hysterophorus* Linn. (65.38 %), leaves extract of arusa, *Adhatodavasica* Nees. (55.81%), *Lantana camara* Linn. (51.70%) and untreated control (1.5 %), respectively. The seed kernel extracts of *A. indica* differed
significantly from the remaining ones except *V. negundo* from which it does not differ significantly to one another. The effects of carrot grass, *P. hysterophorus* was recorded moderate aphidicidal action while *L. camara* caused the lowest mortality of nymphs and adults of *L. erysimi* among all treated natural products. Of the five plant products tested *A. indica* performed better under all the experimental conditions where as untreated control gave only 01.5% aphid mortality. The concentrations 2.0% are superior to concentration 1.0% and 0.5% concentrations. Similarly maximum aphid mortality was observed after 24 hours of exposure and minimum after 6 hours. The exposure periods of 24 hours was significantly superior to 12 hours and 6 hours in both control and plant products.

**Gupta and Yadav (2012)** studied under laboratory conditions at GBPUAT, Pantnagar, during 2004 and 2005, the role of agrochemicals in an integrated manner with the use of biorational insecticides in combination with other agrochemicals (fungicide, Plant growth regulator PGR) for the control of first instar larvae of *Spilarctia oblique*. The results revealed that mortality of larvae started from 48 h on all fortified artificial diets except two mixtures, (Mancozeb 1X + Miraculan 1X) and (Mancozeb 1X + Miraculan 1X + diflubenzuron 0.5X). Dipel 0.5X showed quick lethal effect on larvae within 2 days among all the combinations. The treatments with dipel; (Miraculan 1X + dipel 0.5X), (Mancozeb 1X + Miraculan 1X + Dipel 0.5X), (Mancozeb 1X + Miraculan 1X + Dipel 0.5X + diflubenzuron 0.5X), (Mancozeb 1X + Dipel 0.5X + diflubenzuron 0.5X), (Miraculan 1X + Dipel 0.5X), (diflubenzuron 0.5X + Dipel 0.5X) and (Miraculan 1X + Dipel 0.5X + diflubenzuron 0.5X), showed less than 50 per cent larval survival, which indicated that all the above combinations even with half dose of dipel are effectively lethal to the pest than dipel alone at recommended dose. Similar observations were also recorded when these treatments
were repeated with larvae exposed to treated castor leaves, which proved that the lethal effect of miraculan and mancozeb remained stable when sprayed with dipel or diflubenzuron on plant leaves.

**Islam and Omar (2012)** revealed that biological control, particularly by entomopathogenic fungi is important for reducing the population density of pests in Integrated Pest Management (IPM) programs. The compatibility of entomopathogenic fungi with crop production techniques such as the use of insecticides is needed to understand, which may inhibit to a smaller or larger extent the development and reproduction of pathogen. The efficacy of microbial control agent could be enhanced by applying them in conjunction with reduced rates of insecticides. The interaction between these control agents could be additive, synergistic, or antagonistic. Synergistic interactions would enhance the effectiveness of the microbial control agent while reducing the adverse effects of pesticides. In this review, we will describe the compatibility of entomopathogenic fungus, *Beauveria bassiana* and botanical insecticide, neem.

**Ribeiro et al. (2012)** reported the effect of aqueous extracts and commercial formulations of plants with insecticidal activity on *Beauveria bassiana* in vitro. The treatments comprised the botanical insecticides Neempro (Azadiractin + 3-tigloylazadirachtol), at the concentrations of 0.25, 0.5, 0.75, and 1.0% (v/v), and DalNeem (neem oil emulsifiable), at 0.5, 1.0, 1.5, and 2.0% (v/v) [both commercial formulations of *Azadirachtaindica* (neem)], and the aqueous extracts, at the concentrations of 2.5, 5.0, 7.5, and 10.0% (w/v), of neem seeds, tobacco powder (*Nicotianatabacum*), and catigua leaves (*Trichiliaclausenii*). In potato, dextrose, and agar culture medium, the effects of each product on the mycelial growth and the production and viability of conidia of *B. bassiana* were estimated. According to the
adopted compatibility index, the aqueous extracts of neem seeds and leaves catigua, depending on the concentration used, and the botanical insecticide Neempro, were classified as compatible with the entomopathogen, becoming important alternatives to integrate programmes of integrated pest management, especially in organic farming systems.

Rocha (2012) reported that pathogenicity of Beauveriabassiana (UESC-1, UESC-11 and UESC-38 to 107 conidia mL^{-1}) and commercial products Boveril [registered trademark], Azamax [registered trademark] and Neemseto on adult Metamasiushemipterus L. and assessing the compatibility of the in vitro isolated from fungi and Boveril [registered trademark] in commercial products to neem. Commercial products, Azamax [registered trademark] and Neemseto were evaluated by the action of spraying and intake in concentrations 5.0, 2.5, 1.25, 0.625, 0.312%. The compatibility was evaluated by vegetative growth, the number of conidia and viability of spores of entomopathogenic fungi. The average mortality of the insects was 63.0% [Azamax (registered trademark)] and 58.67% (Neemseto) in concentrations between 0.625% and 1.25% mortality was higher than 50%. Isolates UESC-11, and UESC-38 Boveril [registered trademark] did not differ, with confirmed mortality from 28.0% to 50.0%. It was found that commercial products Azamax [registered trademark] and Neemseto influenced growth in the number of conidia and germination of the fungus, but by the biological indicator of neem based products are compatible with the fungi evaluated.

Sangeetha and Arivudainambi (2012) revealed that management of E. machaerales using various bio-products was conducted to find out the effective product at effective dose. Among the group of bio-product viz., Metarhiziumanisoleae, Beauveriabassiana, Bacillus thuringiensis, Grub kill (a
commercial formulation of the combination of 33% Metarhizium anisopliae, 33% of
*Beauveria bassiana* and 33% of *Bacillus subtilis*, Neem seed kernel extract (NSKE),
neem oil (Azadiractin 0.03% based commercial formulation) and five leaves extract
(a traditional preparation of five different plants such as *Adhatoda vasica*,
*Vitex negundo*, *Azadirachta indica*, *Ricinus communis* and *Pongamia glabra*) tested
against third, fourth and fifth instars of *E. machaeralis*, *Bacillus thuringiensis* @ 1.5%
was effective. This was followed by Grub kill @ 2% and five leaves extract @ 6% in
the field.

**Bhadouria et al. (2013)** studied eight isolates of *Beauveria bassiana* isolated
from different insect hosts and from different locations at Pantnagar (Uttarakhand),
characterized by PCR-based RAPD markers. Bioassays were conducted by using first,
second and third instar larvae of *Spilarctia obliqua* in order to categorize the isolates
based on virulence. The isolates were arbitrarily rated as more virulent, moderately
virulent and less virulent based on the speed of killing. A wide range of variation in
virulence was observed and the isolates of same insect origin and location showed
differences in their aggressiveness. No correlation was found between the
pathogenicity of the isolates and the relatedness of the original insect host. The
pathogenicity against first, second and third instar larvae of *Spilarctia obliqua* did not
reveal any relatedness with the clustering pattern.

**Meyers et al. (2013)** reported that an unexpected outbreak of a native
longhorned beetle, the red oak borer (*Enaphalodes rufulus* (Haldeman)), occurred in
upland oak forests of Arkansas, Missouri and Oklahoma ca. in 1999-2005. Few
management tools exist for reducing *E. rufulus* populations. Laboratory bioassays
were conducted to determine susceptibility of all *E. rufulus* life stages to the fungal
pathogen *Beauveria bassiana* Vuillemin. Egg, neonate, early-instar, pupal, and adult
stages of *E. rufulus* were all susceptible to a natural isolate of *B. bassiana* collected from *E. rufulus* (ARSEF 7404) or a commercial *B. bassiana* product, Botani Gard Reg. In July 2003, 10 living, *E. rufulus*-infested northern red oak (*Quercusrubra* L.) boles were sprayed with a 2 L Botani Gard Reg. *B. bassiana* suspension of 1.3 x 1011 viable conidia per 2 m of each bole at a forested site in the Ozark National Forest, Franklin County, Arkansas. The following spring, trees were removed and sampled for *E. rufulus* larvae that had survived or died during the winter. Live *E. rufulus* larval density in untreated *Q. rubra* log samples was significantly greater than in treated log samples with means of 16.4 ± 1.8 (SE) and 4.4 ± 2.0 larvae per m² of bark for untreated and treated logs, respectively. Application of *B. bassiana* spray against early-instar *E. rufulus* would be most effective in mid-summer of odd-numbered years to target vulnerable early *E. rufulus* life stages and to reduce structural damage to trees caused by *E. rufulus* feeding.

**Sunil and Chandrashekar (2013)** reported that seasonal incidence of frequently occurring leaf eating pests of mulberry for two annual cycles from Aurangabad district of Maharashtra state. The survey was conducted during June 2009 to May 2011. The result shows that, different pests are damaging the Mulberry crop from the study area which causes heavy economical loss to sericulture farmers. The pests occurred were leaf roller, Bihar hairy caterpillar, cutworms, Red hairy caterpillar, Jassid / leaf hopper, Southern green stink bug / Pentatomid bug, Tree hoppers, Litchi bug, wasp moth and wingless grasshopper etc. In the present study classification, occurrence and type of damage and symptoms of the defoliator insect communities was also worked out in the mulberry field from various sites in Aurangabad district of Maharashtra state, India.