SUMMARY

Man is fighting constantly against insect pests. Billion of dollars worth of growing crops are lost to these enemies (Insect pests) annually. Many forms of combats are used in the warfare against insects. Natural control, plants breeding, different chemicals are found effective to control insect pests. Resistant type of grains and vegetables are being developed. All these methods have value but for protection of crops, dependence must first be placed on the use of chemicals. Farmers used different chemicals to control D. obliqua but older larvae survived the toxicity of chemical insecticides. These chemicals also created many side effects on non target animals and plants, development of resistant population, hazards to human health and pollution to environment.

With the growing realization of hazards and side effects connected with the use of chemicals, entomologists have developed IPM which utilizes all suitable techniques and methods in compatible manner and maintain the pest and economy. In recent years, entomologists used different microbial agents for the pest suppression and found very effective against different pests of crops. Now a days a number of bio – pesticides have been registered for field application on different crops of agricultural, horticultural and forest importance. Entomologists used Bacillus thuringiensis for controlling lepidopteran,
coleopteran and dipteran pests. It kills insects primarily through the action of δ-endotoxins; it affects the insect mid gut epithelium upon ingestion.

*Bacillus thuringiensis* is an aerobic, gram positive, spore forming bacterium found rather commonly in the environment. It produces many insect toxins. *Bacillus thuringiensis* was described by Berliner in 1911 but its potential as an insecticide was recognized in 1980. Now a days various formulation of *Bacillus thuringiensis* such as dipel, thuricide, bactospeine, biobit, javelin etc. are available for controlling the lepidopteran pests. These insecticides are considered safe to the environment and natural enemies. So *Bacillus thuringiensis* insecticides are considered safe components in IPM programmes.

The compatibility of *B. thuringiensis* with many chemical insecticides warrants the study to explore its feasibility under IPM system considering the aforesaid facts in view, following studies have been planned against *D. obliqua*.

1. The effect of different formulations of *B. thuringiensis* on growth and development of *D. obliqua*.
2. The effect of biological preparations on fecundity and fertility of *D. obliqua*.
3. Compatibility of Dipel with certain commonly used insecticides.

*Diacrisia obliqua* is a polyphagous insect. Moths feed on potato, tomato, sunflower, castor, jute and many other plants and cause mild to severe loss. Larvae feed on leaves, buds and flowers of different host plants and sometimes, the plants may be defoliated. Moths are medium sized. The wings
are pale buff coloured. Males and females are usually identical in appearance. The female is bigger than male. The abdomen of female is wider and stumpy. Adults mate soon after emergence. A female lay about 300-400 eggs during her life time. The eggs are small, spherical, pale or yellow in colour. The eggs stage lasts for 3-4 days. Newly hatched larva is dark grey, measuring about 2 mm in length. The full grown larva is about 40 mm in length. Larva moults four times to make the number of instars five. The larval period lasts for 13 to 28 days. Pupation takes place in soil in a silken cocoon. The pupa is reddish brown and its length is about 2 cm. Adults emerges out from the pupa in 5 to 10 days. The life cycle is completed in 28 to 42 days depending on the season.

Since large number of insects/larvae of D. obliqua was required for different experimental works, the pest was collected locally and cultured in the laboratory on the natural diet. From these, test insect/larvae of known age and stage were taken as per experimental requirement.

Moths were maintained in glass chimneys with castor leaves. Eggs obtained from them were kept for hatching in petridishes. Larvae hatched from eggs and were placed on tender castor leaves in petridishes and reared on them till pupation. All possible measures were taken to save larvae from bacterial and fungal infections. The first and second instars were reared in petridishes and from third instar to pupation they were reared in pneumatic troughs in small groups. Moths emerged from pupae were maintained in glass chimneys for oviposition. In this way the progeny of moth were reared generation after generation till the tenure of the investigation. The commercial preparations of B.
*Thuringiensis*, dipel, thuricide and bactospeine were selected for this investigation.

The concentrations considered in this study included 0.05, 0.10, 0.50, 0.75 and 1.0 per cent. These concentrations were obtained by dissolving the desired quantity of microbial preparations in distilled water. Different concentrations were prepared by serial dilution method. Two per cent skimmed milk powder was added to bacterial suspension for improving the adhering quality of the solution. The insect was treated with different concentrations of microbial preparations used in this investigation by two methods namely, leaf dip method, and topical method. Studies were conducted experimentally under laboratory conditions.

Effect of biocontrol agents (*Bt.* insecticides) was studied in terms of accumulations of biomass in larva at regular intervals (5\textsuperscript{th}, 10\textsuperscript{th} and 15\textsuperscript{th} day) and acquisition of biomass in both pupa and adults was evaluated.

Larva of the control experiment accumulated 4.28 mg biomass on the 5\textsuperscript{th} day. Whereas the larval biomass on the 5\textsuperscript{th} day varied from 1.84 to 4.15 mg under influence of different concentrations of different bio control agents when applied by leaf dip method. By leaf dip method different bio- insecticides at 1.00 per cent concentration showed larval biomass as dipel (1.88 mg), thuricide (1.84 mg) and bactospeine (2.06 mg) in ascending order.

Under topical method of treatment, different concentrations of bio-pesticides used in this investigation caused change in larval biomass on 5\textsuperscript{th} day in comparison of control experiment (4.28 mg). Under topical method at one per
cent concentration different Bt. insecticides showed larval biomass as dipel (1.94 mg), thuricide (2.00 mg) and bactospeine (2.18 mg) in ascending order.

On 10th day of the larval development the control larvae had 22.68 mg biomass. On the same day, under leaf dip method of treatment different concentrations of all Bt. insecticides used in this investigation influenced the larval biomass and it was varied from 6.66 mg to 21.68 mg. The biomass of the larva exhibited the tendency of decrease with increase in the concentration of Bt. insecticides on this day of development.

Under topical method of treatment, on 10th day of the larval period, every concentration of every Bt. insecticide used in this investigation influenced this period in comparison of control experiment (22.68 mg). It was varied from 6.84 to 22.24 mg.

The biomass of the control larva was 99.90 mg on the 15th day and it was significantly more than that of the larva on the same day under influence of any concentration of all Bt. insecticide used in this investigation. In response to leaf dip treatment, the biomass of the larva on 15th day varied from 23.26 to 88.48 mg and under the topical method of treatment, the larval biomass also influenced by every concentration of all microbial preparations used in this study. The biomass of the larva varied form 24.85 to 90.43 mg and it differed significantly with strength of Bt. insecticide. The biomass of the larva decreased differently with increase in the concentration of the dipel, thuricide and bactospeine.
Pupa obtained from the untreated adults acquired 132.64 mg biomass which was considerably more than that of the pupa obtained from the adults treated with bio insecticides topically or by leaf dip method. Weight of the pupa varied from 64.46 mg to 130.46 mg in response to different concentrations of different microbial preparations used for treatment by leaf dip method. Under topical method of treatment, the weight of the pupa varied from 68.83 to 134.68 mg in response to different concentrations of Bt. insecticides and it was detected to differ with the concentration and decrease with the increasing concentration.

The male moth obtained from the untreated stock was heavier (99.86 mg) than that obtained from pupae earlier treated by leaf dip method with any concentration of any microbial insecticide used in this research study. Weight of the male varied from 46.63 to 94.59 mg in response to different Bt. insecticides and as per analysis of variance, the weight of the male moth depended on concentration of the Bt. insecticide with a clear tendency to decrease with increasing concentration.

In response to topical treatment with different concentrations of Bt. insecticides, the male weighted from 50.78 mg to 99.72 mg and it appeared to decrease with increase in the concentration of the Bt. insecticides (Dipel, Thuricide and Bactospeine) used in this study.

The female moth obtained from untreated adults acquired more biomass 103.65 mg than that obtained from the treated stock. As regards the effect of different concentrations of Bt. insecticides used in this study, the biomass accumulated by the female moth varied from 56.26 to 100.88 mg.
decreasing with the increasing concentration of the biological preparations and
the analysis of variance test should it to be dependent on the concentration of the
Bt. insecticide (P < 0.01).

Female obtained from the pupae earlier treated with any
concentration of any Bt. insecticide by leaf dip method acquired weight from
53.62 mg to 100.63 mg and it was dependent on the concentration of the Bt.
insecticide (P < 0.01) and it decreased with increase in the concentration.
Female obtained from topically treated stock acquired weight from 56.26 to
100.88 mg and it was also found dependent on the concentration of the Bt.
insecticides (Dipel, Thuricide and Bactospeine) significantly (P < 0.01).

The larvae of the adults of the untreated stock had considerably
more survival (85.43 %) as compared to those of the treated stock. In response
to treatment by leaf dip method the survival of the larvae varied from 22.14 to
72.76 per cent decreasing with the increasing concentration of the tested Bt.
insecticides. Whereas that of adults treated by topical method with any
concentration of used Bt. insecticides acquired survival in the range between
25.42 to 76.25 per cent (p < 0.01).

Further, the larva of the untreated stock grew faster than that of
larva of treated stock with any concentration of any used microbial preparation
either by leaf dip method or by topical method. As regards influence of different
concentrations of the Bt. insecticides by leaf dip method, the duration of larval
stage varying from 20.65 to 36.46 days whereas that of adults treated topically
with any concentration of any microbial preparation used in this study, the
duration of larval stage varying from 19.08 to 40.43 days and found increasing with the increasing concentration of *Bt.* insecticides was detected to depend on the concentration (P < 0.05).

The pupa of the untreated adults had hundred per cent emergence which was much curtailed in case of the pupa treated either by leaf dip method or by topical method with any concentration of all *Bt.* insecticides used in this investigation. In response to treatment by leaf dip method, the percentage of the emergence, varied from 22.72 to 71.82 per cent. Further, in response to topical treatment, the percentage of emergence was varied between 25.74 to 75.72 per cent and in both types of treatments it was found decreasing with the increase in the concentration of used microbial preparations (Dipel, Thuricide and Bactospeine) significantly.

There was significant difference in the pupal period between the non treatment condition and the treatment situation at any strength of used *Bt.* insecticides. The pupal period was prolonged considerably by all concentrations of all used microbial preparations. The pupal period varied from 14.52 to 29.76 days under leaf dip treatment and it varied from 14.94 to 30.41 days under topical method of treatment and found increasing with the increase in the concentration, depended significantly on the strength of the *Bt.* insecticides (P<0.05).

Under the both methods of treatments with any concentration of all *Bt.* insecticides used in this investigation curtailed the longevity of both male and female adult's significantly as compared parent adult's non treatment (P < 0.05).
The male moth lived 3.14 to 7.92 days under the treatment by leaf dip method while under topical treatment the male survived only from 3.45 to 8.60 days. The female moth survived from 3.16 to 8.35 days under treatment by leaf dip method and from 3.36 to 9.76 days under topical treatment with used bio controlling agents. It was also observed that the female lived longer than male. The life span in either sex, decreasing with the increasing concentration, differed significantly with the concentration of the used *Bt.* insecticides in this investigation (*P* < 0.05).

The net mortality, varying from 34 to 96 per cent among different concentrations of the different *Bt.* insecticides used in this research study when applied by leaf dip method and topical method and appearing to be directly proportional to the concentrations, depended on the concentration of *Bt.* insecticides (*p* < 0.05). Under leaf dip method, the net mortality was found from 34 to 96 per cent while under topical method, the net mortality, varying from 34 to 88 per cent. Among different concentrations of different microbial preparations, as per chi-square test, it differed from concentration to concentration significantly (*P* < 0.05).

The sexual maturity of the adults in response to treatment by leaf dip or topical method with any concentration of any *Bt.* insecticide used in this investigation affected the pre-oviposition period, appearing to decrease with the increasing concentrations. The pre-oviposition period was recorded from 2.64 to 3.86 days under the treatments with *Bt.* insecticides by both methods of treatment applied in this investigation.
Every concentration of used *Bt.* insecticides influenced the duration of oviposition period. Under leaf dip method, the oviposition period was recorded from 2.12 days to 5.38 days. While under topical method of treatment, the oviposition period was observed between 2.24 to 5.62 days. The analysis of variance test revealed that the oviposition period depended on the concentration of the microbial preparations (p < 0.05).

As regard the effect of different concentrations of the *Bt.* insecticides used in this study, applied by leaf dip method/topical method, the number of eggs laid per female was variable. It varied from 40.4 eggs to 131.4 eggs among them under leaf dip method of treatment. Under topical method of treatment the number of eggs laid by per female varied from 50.3 eggs to 137.5 eggs. Under both types of treatments, it was observed that the number of eggs laid/female increased with the decreasing concentration and differed significantly (P < 0.05).

Every concentration of used *Bt.* insecticide in this research work caused reduction in hatchability of eggs considerably (p < 0.05). As regards the influence of different concentrations of different microbial preparations on the hatchability of eggs, it varied from 8.3 per cent to 61.5 per cent under leaf dip method of treatment and decreasing with the advancing concentrations, depended strongly on the concentration, (P < 0.05). Under topical method of treatment, the percentage of hatching varied from 14.6 to 62.7 per cent and tending indirectly proportional to the concentration affected differently by different concentrations of the microbial insecticides (P < 0.05).
Every concentration of the different microbial preparation applied topically/leaf dip method prolonged the egg stage as compared the non-treatment condition (P < 0.05). In response to leaf dip method treatment with different concentrations of Bt. insecticides applied in this research study, the incubation period varying from 3.16 days to 5.42 days, and prolonging with the increasing concentrations of the microbial preparations depended strongly on the strength of the Bt. insecticide (P < 0.05). Further, every concentration of the different Bt. insecticides applied topically also prolonged the incubation period (3.16 to 5.02 days) delaying with the advancing concentration differed from concentration to concentration significantly (P < 0.05).

As regards the effect of different concentrations of Bt. insecticides used in this investigation, applied by leaf dip method, the per cent reduction in fecundity (27.5 to 79%), per cent net sterility (6.78 to 86.38%) and per cent control over reproduction (34.2 to 94.6 %) were observed. Under topical method of treatment, the percentage of reduction in fecundity (26.8 to 72.7%), the percentage of net sterility (5.93 to 80.40%) and the per cent control over reproduction (34.3 to 94.0%) were found and tending indirectly proportional to the concentration affected differently by different concentrations of the dipel, thuricide and bactospeine (P < 0.05).

The mating between untreated female and treated male (By leaf dip method) reduced fecundity 91.4 to 109.2 eggs/female as compared the mating between untreated sex partners (346.2 eggs/female), it caused reduction in hatching percentage (45.65 to 55.96). The cross between the untreated male &
treated female also inducing the fecundity (81.7 to 89.2 eggs/female). The percentage of hatching was found very low i.e. 31.4 to 42.42. However, mating between the treated male and treated female, there was further reduction in fecundity 70.4 to 84.0 eggs/female) & the percentage of hatching of eggs was recorded between 15.71 to 25.12 only.

Compatibility of dipel with different insecticides (Endosulfan, BHC, Malathion, Quinalphos, Cypermethrin and Fenvelerate) against the five days old larvae of *D. obliqua* was also studied. The relative toxicity and toxicity index of all the six insecticides tested and available data clearly showed that cypermethrin was the most toxic insecticide followed by Fenvelerate, Quinalphos, Endosulfan, Malathion and B.H.C. It was also observed that there was a negative co-relation between LC50 values and toxicity index of the insecticides. On the basis of bioefficacy test, the toxicity of insecticides can be arranged in the following descending order:

Cypermethrin>Fenvelerate>Quinalphos>Endosulfan>Malathion>BHC.

As regards the effectivity of insecticides in combination with sublethal concentration of dipel, data showed increased toxicity of each insecticide. Results showed that combination of bacterial toxin with lower concentrations of each insecticide resulted in high rate of larval mortality.

As far as the effect of dipel on the toxicity of insecticides, the result showed the marked influence on the toxicity of insecticides. It contributed (3.37 times) toxicity when mixed with Quinalphos, whereas it was minimum (2.085
times) in combination with cypermethrin. The response of *Bacillus thuringiensis* with insecticides, showed the following order of toxicity:

Quinalphos > Malathion > BHC > Endosulfan > Fenvelerate > Cypermethrin.

As regards the effect of dipel on the toxicity of chemical insecticides, the findings elicit that mixing of dipel with chemical insecticides resulted in increased toxicity of each tested chemical, though maximum response was imparted to Quinalphos.

The present research work reveals that the bacterial preparations (Dipel, Thuricide and Bactospeine) have proved to be best controlling agents without disturbing our ecosystem. These *Bt.* insecticides caused remarkable mortality in larvae and affected growth and development of *D. obliqua*. The fecundity and fertility also affected differently, so these results are of significant in the pest management programme as damage by *D. obliqua* will be reduced substantially.

In the light of findings, the use of bacterial preparations may be under taken singly or in combination with chemical insecticides with remarkable success to keep the population of *D. obliqua* below economic threshold. It may be concluded that all microbial preparations used in this study are suitable for use in integrated pest management programmes against *D. obliqua*. 

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