CHAPTER - VII
7. DISCUSSION

Host range:

Phytophagous insects are generally oligophagous or polyphagous, of which the tendency of becoming a polyphagous insect is very much significant in the context of plant protection (Ananthakrishnan, 1992). It is because, they not only increase their host range for feeding, shelter and survival but they pose challenges to Entomologists for field control in different cropping systems. Feeding and breeding are two related processes for which organisms in general associate with their respective hosts (Dethier, 1954). Some insects always maintain oligophagous character. As for instance, the common crucifer pests like *Plutella xylostella* (L.), *Pieris brassicae* (L.) and *Pieris canidia* (Sparrman) etc. infest always members of cruciferae (Nair, 1986). On the other hand, few insects like *H. armigera* (Hub.) and *Spodoptera litura* (F.) are notorious polyphagous pests (Manjunath, 1992, Ray & Banerjee, 1993) and being considered to a status of even *national pest* (Jayaraj et al., 1994). The caterpillars of *S. obliqua* are currently considered as a sporadic pest, but they gradually expand their host spectrum from 75 plant species (Deshmukh et al., 1976) to 126 species based on the present work. This would mean that over a period of 25 years nearly 50 plant species have become additional hosts and proportionately their survival chances too increased considerably. Although, it is remarkable for the insect, it gives us worry in terms of population control.
Moreover, colonies of *S. obliqua* have been found in Manipur on the fencing weed, *I. cornea* and the oak plant, *Quercus serrata* a primary food plant of tasar silkworm, *Antheraea proylei* Jolly (Rajen & Varatharajan, 1999). Therefore, considering its importance, the biology of this pest has been dealt with the weed *I. cornea* in the present thesis. Further, the literature survey on host record has also indicated more affinity with leguminous crops than with other families. Secondly, out of 126 species of hosts, 90% are economically important plants and 10% form the weeds, the latter may serve as reservoir and sustain their density during off-season of the crop plants. In view of the above, the present attempt on updating the host list of *S. obliqua* gains significance.

**Biology:**

Studies on the comparative approach of the biology of *S. obliqua* especially on *Phaseolus vulgaris*, *Brassica juncea* and *Ipomoea cornea* revealed that the crops *P. vulgaris* and *B. juncea* were found to be better hosts than the weed *I. cornea* in terms of larval duration, fecundity, adult longevity and intrinsic rate of insect's growth and density (Tables - 1 to 3). Further, when the larvae were reared at the same indoor climatic conditions, the duration of development of immature stages of *S. obliqua* was 43 days on *P. vulgaris* and 47 days on *I. cornea* (Table – 2). The fecundity rate showed significant difference with 1160, 900 and 602 eggs on *P. vulgaris*, *B. juncea* and *I. cornea* respectively. Similarly, the intrinsic rate of population growth also showed same trend with the maximum number in *P.*
vulgaris and minimum in I. cornea (Figure- 4 ; Table -3). The length as well as width of head capsule also showed significant difference i.e., the head capsule size was appreciably bigger in those larvae reared on P. vulgaris than that of larvae cultured on I. cornea (Table -10 & 11). While comparing the above parameters, it is evident that P. vulgaris is a better host than I. cornea. Similar observations on the performance of insects reared on crops and weed include thrips (Chochong et al., 2002), grasshopper (Sanjayan & Murugan, 1987), plant bugs (Raman, 1987; Velayudhan, 1987) and certain species of Lepidopterans (Muthukrishnan et al., 1993; Ray & Banerjee, 1993). But as early as 1958, Johansson observed that, the quality and quantity of food influence the pre-oviposition period and fecundity in the dusky cotton bug (Oxycarenus laetus Kirby). The above observations on varied groups of insects indicate that feeding and reproduction are closely related to nutritional factors, the qualitative and quantitative aspects of which have an impact not only on fecundity but also on the rate of growth and development. Therefore, appreciably little higher fecundity and short duration of larval development of S. obliqua on P. vulgaris and B. juncea could be attributed to the presence of better quality and quantity of nutritional factors in the above said crop plants than that of the weed I. cornea. Although, chemical analysis of the plant host has not been done in the present work, it is a known fact that crops are always superior to weeds in terms of nutritional parameters (Dadd, 1977).
Food consumption:

Phytophagous insects can be highly selective with respect to the plant they consume and that both the degree of selectivity and the identity of preferred plants may vary between the insect species. It is widely recognised that plant species can differ in quality or suitability for insect growth, survival and reproduction. It is because mere establishment of an insect on a particular plant will not provide a clear picture on host suitability. But an understanding of the efficiency of utilization of plant resources in terms of quantitative measure will provide an incisive picture in any investigation relating to insect - plant interactions.

In the present work, analysis on the food consumption of *S. obliqua* revealed that food consumption index (CI) decreased with increasing stage of the larva. For example, the consumption index of IV, V and VI instars of *S. obliqua* was 3.75, 2.64 and 0.89 mg/larva respectively, when fed on *P. vulgaris*, whereas it was 4.99, 2.82 and 1.42 mg/larva when the above concerned larval instars were reared on the weed *I. cornea* (Table –12).

The growth rate (GR) was also found to be directly proportional to the respective consumption index (Table –12). Comparatively higher food intake of *S. obliqua* on *I. cornea* was suspected to be due to nutritional deficiency of the host, which perhaps forced the larvae to consume more food in order to fulfil their nutritional requirement. Similar interpretation was also given by Ganga
et al., (1985) with respect to high CI on the beetle, *Henosepilachna septima* fed on the host *Luffa acutangla* Roeb. The above view appears to be quite plausible and acceptable in the present context because basically *I. cornea* is also a weed.

The decrease in CI from IV to VI instar indicates the voracious feeding nature of the early stages. This trend has also been observed in certain insects like *Spodoptera litura* (Bhat & Bhattacharya, 1978); grasshoppers and locusts (Mehrotra *et al.*, 1972; Sanjayan & Murugan, 1987). Slansky (1982), while discussing the general trend on insect nutrition, highlights the tendency of young individuals being capable of consuming more food than adults, although exceptions always exist in any group/system. In the present study, the increase in CI of IV instar could be attributed to its growth phase exhibiting higher growth rate than V and VI instars and also its group feeding competitiveness on the same foliage (Plate -3). Mention may be made here that IV instar usually occurs in groups of 17-22, while V and VI instar, occur in groups of 6-8 and 2-4 individuals respectively per leaf. Further, the approximate digestibility (AD) was also found to be more for IV instar than the two late instars and due to all the above said features, the CI was also more for IV instar (Table –12).

Although approximate digestibility (AD) decreased with increasing age of the caterpillar, the efficiency of conversion of ingested food (ECI) as well as conversion of digested food (ECD) increased with the age of the larvae. This was evident in the larvae of *S. obliqua* reared on *P. vulgaris* and *I. cornea*. 
Similar trends on AD, ECI and ECD values were obtained in a number of insects (Sanjayan & Murugan, 1987; Jacob, 1992; Sudarsana, 2001). Waldbauer (1968) was also of the opinion that the value of ECD would not decline with increasing age of the insect and more the efficiency of conversion of ingested and digested food, greater would be the chance for larval growth and development.

**Climatic factors:**

Despite the fact that host plants play an important role in feeding and breeding of *S. obliqua*, still the climatic factors have almost equal role in their growth, development and population build-up. Studies made in this respect especially on the host *P. vulgaris* and *I. cornea* during different seasons (spring, summer, autumn) revealed significant difference between the period of rearing in terms of performance of the insect, even though the insect was reared on the same plant species. The duration of development, fecundity, intrinsic rate of population growth etc. showed considerable variation among the rearing period (Tables -3 to 8). Out of the three seasons, July - August appeared to be very much conducive for *S. obliqua* in terms of breeding, quick development and maintaining appreciable level of population (Tables -5 to 8). This observation is in agreement with that of their field density, wherein, the natural populations of *S. obliqua* were also found to breed and maintain appreciable density during June to August.
Assessment on the population of *S. obliqua* in the Imphal valley over a period of four years (1999 – 2002) indicated that the insect has been found active from March to November with maximum population during July and August. It appears that during December to February, it hibernates due to winter effect. This trend on field density has revealed that the following three factors primarily regulate the natural population of *S. obliqua*. They are:

(i) Climatic factors (abiotic factors)

(ii) Host plants (biotic factor)

(iii) Natural enemies and pathogens (biotic factors).

**Role of abiotic factors:**

Climatic factors like temperature, humidity, photoperiod and rainfall play a predominant role in the field regulation of *S. obliqua*. The analysis of the field data especially during the period of their maximum abundance (*i.e.*, during July) with that of climatic factors of respective month showed that an average maximum temperature of $29.3 \pm 1.5^\circ\text{C}$, minimum of $22.5 \pm 0.5^\circ\text{C}$ with $80 \pm 4\%$ relative humidity and 13 hours of day length were found to be conducive for the growth and survival of *S. obliqua*.

Of course, every insect species survives at a particular range of temperature and humidity and the tolerance level indeed varies from species to species (Southwood, 1972). The threshold level of thermal tolerance of certain insect has already been documented by a number of researchers (Price, 1975;
Nayar *et al.*, 1976; Varley *et al.*, 1980). However, under the climatic conditions of Indian subcontinent, the outbreak of caterpillar pest in general, has been found to be during the period of south-west monsoon *i.e.*, from June to August (Ananthakrishnan & Viswanathan, 1976). The present observation on the abundance of *S. obliqua* is in tune with the above trend.

**Role of plant hosts:**

Unlike abiotic factors, plants always provide protection to phytophagous insects, as a result, they feed and breed on the host concerned (Jermy, '1984). This kind of host dependency is part of the insect-plant interaction in which the insect selects primary, secondary and tertiary hosts based on its nutritional requirements and other considerations for breeding (Feeny, '1975). It has been observed in the present study that, during the active phase *i.e.*, from March to November, *S. obliqua* infests various crops at different levels, thereby exhibiting preference over other plants in terms of feeding, breeding and colonization. Among the plants examined, species such as *Phaseolus vulgaris* L., *Glyxine max* (L.) Merrill, *Helianthus annuus* L. and *Ricinus communis* L. were found to be preferred hosts in terms of population build-up by the pest. Therefore, the infestation level was also found to be appreciably high on these hosts with mean density ranging form 8-10 larvae per plant (Table -A). Although, nearly 21 plants have so far been recorded as hosts from the state of Manipur, by and large the oil seed and pulse crops harbour them to a great extent. This
observation is corroborated by comparative studies on biology of S. obliqua, in which the larvae have been reared individually on P. vulgaris, R. communis, H. annuus, G. max and few other hosts, wherein appreciably good performance of the insect has been noted on pulse and oilseed crops in comparison to other hosts (Deshmukh et al., 1979; Nagia et al., 1991 and Singh & Sehgal, 1992).

The continuous monitoring of larval density for four years on varied hosts has also revealed the establishment of colony on different plants at different seasons. For instance, the initial colony formation has been observed primarily on the weed, Ipomoea cornea Jacq. during all the four years and the life stages of S. obliqua make use of I. cornea till May. The crucifer winter crops also facilitate the colonization of S. obliqua to some extent, but in comparison to Ipomoea, their role appear to be negligible. From this weed, they move on to either pulses or oil seeds or cereals or summer vegetable crops (Figure -2). Among them, P. vulgaris, G. max, H. annuus and R. communis enable this pest to maintain appreciable density till the onset of winter. Such trend has been observed in all the four years of study period.

Presence of different plant species in a given habitat at varied seasons promotes the occurrence of S. obliqua continuously from March to November, especially under the climatic conditions of Manipur. In this context, in addition to the pulses and oilseed crops, the perennial fencing weed Ipomoea plays an important role because it helps in the populations sustenance of S. obliqua.
In general, weeds act as at least temporary reservoir for pests (Ananthakrishnan, 1992). Moreover, presence of weeds within and around the crops considerably influence the dynamics of crops and associated biotic communities in an agro-ecosystem. In addition, it harbours periodic outbreak of pest species (Way & Cammel, 1981; Altieri, 1986). This is exactly evident in the present system and therefore, *S. obliqua* thrives on weeds and crops almost round the year, excluding winter months.

**Distribution pattern on the foliage:**

Another striking feature is their distribution and feeding pattern on the plant host. As the gravid female lays eggs in cluster, the emerging larvae occur in a colony of more than 250 individuals per leaf till they reach II instar and about 25 larvae in the case of III instar (Table –13 & 14; Plate – 3). Therefore, their feeding areas have been confined to either one or two foliages per plant. On the contrary, instars like IV, V and VI inhabit the leaf in small groups of 2-7 individuals per leaf and their average feeding rate as for example on *P. vulgaris* being 3.75, 2.64 and 0.89 mg/larva/instar respectively when they are fed with fresh foliage as per gravimetric method (Waldbauer, 1968). This data also reflects the extent of damage that they can cause. For instance, by correlating its biology with the feeding rate, it is possible to say that out of 30 ± 2 days of larval duration, the damage caused by a colony during the first 13-15 days *i.e.*, up to III instar will be invariably one or two foliage per plant. But the later
three stages of the caterpillars not only exhibited potential feeding propensity but also enhanced their chances of inter as well as intra plant movements, thereby causing appreciable damage to the crop. Therefore, suitable control measures need to be exercised before they reach IV instar.

**Role of Parasitoids in the population regulation:**

It is clear from the foregoing points that the caterpillars of *S. obliqua* is capable of establishing the colony on a number of hosts and further, the climatic factors also favour in their population build up to some extent, as a result of which the intrinsic rate of population also increases to an appreciable level. For instance, the intrinsic rate of increase of number (*r*<sub>m</sub>) was 0.13 on *I. cornea* and 0.15 on *P. vulgaris* and the population doubling time was 5.31 and 4.52 days respectively when they were reared under laboratory conditions (Table - 3). But the field density of *S. obliqua* did not increase to that significant level (in the present study) because the natural population of *S. obliqua* were controlled by their natural enemies and diseases. The forthcoming paragraphs highlight their role in the field regulation of Bihar hairy caterpillar. In addition to it, possible effect of pathogens like baculoviruses, bacteria, bioefficacy of neem product (Neemazal) and insect growth regulators (IGR) are also discussed here in the context of ecofriendly approach on insect control.
Parasitoids:

A number of parasitoids have been known to parasitise the caterpillars of *S. obliqua*. Field studies carried out during the last four years revealed the occurrence of three species of parasitoids in the valley region of Imphal. They are:

(i) *Meteorus dichomeridis* Wilkinson

(ii) *Glyptapanteles creatonoti* Viereck

(iii) *Carcelia* sp.

Of the three species, *M. dichomeridis* appeared as dominant one with maximum parasitism of 40% followed by *G. creatonoti* and *Carcelia* sp. with 15 and 6% respectively especially during August (Figure-7), thereby reaching a total of 61% on the plant host *P. vulgaris*. However, for the remaining periods of observation *i.e.*, from May to September, total parasitism ranged from 6.6 to 33% both on *P. vulgaris* and *I. cornea*. The species composition and percentage parasitism of parasitoids may vary from place to place as well as host to host. For instance, the Dipteran parasite, *Carcelia* sp. showed just 6% parasitism in Imphal, while the same parasitoid exhibited a maximum of 28% parasitism in Delhi and its environs (Battu & Ramakrishnan, 1989).

But what was observed to be significant here being the host dependent parasitism *i.e.*, percentage parasitism increased with the density of larvae irrespective of the host, thereby exhibiting significant positive correlation (Table -16b). Although, this feature is not uncommon with host and parasite
such positive relation helps in limiting the chances of pest outbreak to some extent.

**Baculoviruses:**

The baculoviruses are a diverse group of large viruses with double stranded DNA that are pathogenic for invertebrates, primarily insects of the Order- Lepidoptera. The interest in using baculoviruses as pesticide arose from observations involving natural epizootics of larval populations of moths and butterflies, which (virus) in turn regulate the pest density under field conditions (Alanwood, 1995). Moreover, baculoviruses in general have a number of advantages:

(i) They are species specific and therefore infect only the target organism.

(ii) They are naturally occurring soil microorganism and are capable of perpetuating themselves in the field.

(iii) It is easy to augment through *in-vivo* method by the farmers.

(iv) It is easy to apply the viruses using conventional sprayers as liquid formulation.

(v) It is also compatible with some of the common and conventionally used insecticides.

(vi) Application of baculoviruses has so far not resulted in insect resistance/ resurgence or health hazard to spraying personal or environment or wild life.
Based on such merits, about 25 years ago, U.S. environmental protection agency granted full pesticide registration to few viral pesticides (Alanwood, 1995). But only during the last decade, India began to recognise its significance for field use. As a result, viruses like *Helicoverpa armigera* nuclear polyhedrosis virus (HaNPV), *Spodoptera litura* NPV (SINPV), *Amsacta albistriga* NPV (AaNPV), *Oryctes rhinoceros* NPV (OrNPV) and the teak defoliator, *Hyblaea puera* NPV (HbNPV) etc. are now increasingly used against respective host species (Jayaraj et al., 1994). SoNPV also has potential utility against *S. obliqua* for a number of crops but to exploit them effectively for commercial use, basic research is essential. Considering this aspect, studies on the LC\textsubscript{50}, LT\textsubscript{50} of SoNPV, impact of plant hosts and temperature on viral infection have been attempted in the present study.

The LC\textsubscript{50} value of SoNPV (Manipur isolate) against III instar was 2.5 x 10\textsuperscript{4} PIBs/ml and LT\textsubscript{50} of III, IV and V instar larvae being 5.73, 6.45 and 6.96 days respectively. It indicated that with a minimum dose of 2.5 x 10\textsuperscript{4} polyhedra, it is possible to kill 50% of the test population in 6 days and 90% of the population in 9 days (Tables – 18, 19, 22). The LC\textsubscript{50} and LT\textsubscript{50} values obtained here were found to be little different from that of *Helicoverpa armigera* nuclear polyhedrosis virus (Rabindra et al., 1994), *Amsacta albistriga* nuclear polyhedrosis virus (Jayaraj et al., 1976), *Spodoptera litura* nuclear polyhedrosis virus (Muralibaskaran et al., 1996), *Hyblaea puera* nuclear polyhedrosis virus.
(Ahmed, 1995) and even *Spilarctia obliqua* nuclear polyhedrosis virus of North India isolate (Chaudhari., 1997). Such variations are bound to occur because of

(i) plant hosts on which the larvae are reared,

(ii) age of the larvae and

(iii) temperature at which the cultures are maintained (Smith, 1976).

Baculoviruses in general takes 5-15 days to kill the host (Alawi, 1995) and the duration of lethal time has been known to differ with the above said factors. In the present study, it was found that the LT_{50} of III instar was 5.7 days and that of V instar was 7 days, indicating the relation between larval age and susceptibility to viral infection (Table -19).

Similarly, the effect of plant hosts on virus induced larval mortality as well as influence of temperature on rearing of virus infected larvae became clear in the present work (Table -20 & 22). Temperature has profound role in the spread of viral infection. It is known that infectivity of baculovirus is appreciably less and slow at low temperature and the viral infection spreads quickly at higher temperature ranging from 25 – 30°C. Results obtained on SoNPV also highlight the above view on the role of temperature in the context of virus induced larval death (Table -20). Based on such available data, it is now possible to augment the polyhedra of SoNPV at room temperature ranging from 25 – 30°C on suitable host, thereby adequate quantity of viral pesticide can be produced. Moreover, the weed *Ipomoea cornea* also forms an ideal host to rear
the larvae not only by virtue of being a fencing weed, but it is available in all seasons and not much variation with other hosts in terms of LT₅₀ of the larvae. Thus, the present study gives good scope for in-vivo production of SoNPV to an appreciable level for field use against the larvae of *S. obliqua*.

**Effect of Bt on *S. obliqua*:**

In addition to the species specific virus – SoNPV, the Lepidopteran specific bacterial pathogen has been evaluated against *S. obliqua*. In general, bacteria are one of the important effective pathogens of insects (Aronson *et al.*, 1986). Among the different species, *Bacillus thuringiensis* is a promising biopesticide (Buchanan and Gibbons, 1974), which is basically a gram positive soil bacterium. It possesses 4 types of toxins *i.e.*, proteineous crystals (endotoxins), which exhibit various shape and size. Based on such crystal toxic proteins, they are classified into 4 types (Hofte and Whiteley, 1989) which are as follows:

Type I - gene encode 130 KDa Proteins – Lepidopteran specific

Type II - gene encode 70 KDa Protein – Lepidopteran and Dipteran specific.

Type III - gene encode 70 KDa Protein – Coleopteran specific.

Type IV – comprises both 70 and 130 KDa Proteins – active against mosquitoes and blackfly larvae.

In the present study, the Lepidopteran specific *Bacillus thuringiensis* var. *kurstaki*, a non spore forming strain, commercially known as “Bioasp” has been evaluated against the larvae of *S. obliqua*. The laboratory bioassay studies
indicated cent percent mortality of the first 3 instars in 48 hours of treatment, especially at the concentration ranging from 0.1 to 0.4 %, while IV and V instars showed dose dependent mortality i.e. with the increase of dose, death rate of the later instars also increased. But what is significant here is that, just like chemical insecticide, Bt product is able to achieve appreciable level of mortality in 48 hours of treatment. Generally, Bt products are known to be more effective to early instars than later stages of caterpillars (Rabindra & Jayaraj, 1988). Therefore, the present study also confirms the above fact and states further that higher concentrations of Bt need to be used for efficient control of caterpillars of old stages (Table –23 & 24).

**Effect of Neemazal on S. obliqua:**

Among the various methods of pest control, combating the pest density using plant products form a kind of insecticidal control. Farmers in India have used many plant products even prior to the discovery of synthetic chemicals. But the scope for botanicals being so vast that over 2100 plant species have so far been reported to possess pest control properties (Kareem, 1999). Of which, the neem products of the plant *Azadirachta indica* A. Juss exhibit promising future in pest control, because they not only give some relief as an alternative to synthetic pesticides but the neem product is also gaining momentum due to its eco-friendliness and effectiveness against a number of insect species (Schmutterer, 1990; Subrahmanayam, 1990). Although the use of neem leaves,
neem seed kernel extract, neem oil emulsion and neem cake against insect pests has been well documented in our country (Pradhan et al., 1962; Devakumar & Parmar 1993), still research works on different neem formulations have now become imperative for efficient and economic utility in terms of quantity, frequency and timing of application. In this context, observations made in the present study using Neemazal showed varying degrees of abnormalities in the larvae of *S. obliqua* in a dose dependant manner (Figure -12; Plate -8). But at higher concentrations like 0.3 and 0.4%, the larval mortality was 70-80%. Though it is well known that, the neem *Azadirachtin* acts as antifeedant, repellent as well as growth inhibiting agent on a number of insect species (Karnavar, 1987), the present work further substantiates precisely the efficacy of different concentrations of Neemazal on *S. obliqua*, which in turn can be adopted for field use.

**Effect of Insect growth regulators on *S. obliqua***:

Insect growth regulators (IGRs) are categorised as a novel insecticide, which can adversely affect the normal growth and development of insects. Even though IGRs are synthetic chemicals, the toxicity of IGR is appreciably less than that of chemical insecticides. Therefore, IGR is recommended in IPM programmes to use it along with other methods (Retinakaran, 1986). In view of the above, certain IGRs were tested in the present work against III instars of *S. obliqua*. The results of the study indicated that their efficacy enhanced with
increase in the dose of respective chemicals. While comparing their efficacy, the coded compound MJ – 644 was found to be more effective, followed by Match and Cascade and this being evident from their respective LC$_{50}$ value 0.03376, 0.07176 and 0.07377 (Table –29). For instance, at the concentration of 0.25%, the mortality rate of III instar after 96 hours of treatment was 96.7%, 80% and 85% respectively when treated with MJ - 644, Match - 5 EC and Cascade 10 DC compounds (Table –28). The latter two compounds were known for effectiveness against caterpillars in general and to quote a few, species such as Plutella xylostella (Josan & Singh, 1999; Lokare et al., 1999) and Helicoverpa armigera (Vadodaria et al., 2000). Therefore based on the present work as well as on the earlier reports, it is possible to use IGRs as alternate chemical to combat field density of caterpillars.

**Scope for IPM:**

It is now unambiguously proved through various studies that no single method will be viable in the long run to control the insect. Therefore, it is imperative that an integrated approach comprising a number of possible methods such as biological, cultural, natural products, pheromonal and synthetic chemicals becomes essential in any pest control programme. Such combination has been precisely prescribed by FAO (Krishnamurthi, 1982) in order to reduce or avert the side effects that emerge out of synthetic pesticides. Keeping this view in mind, bioassay of Neemazal, IGRs and microbial agents such as SoNPV
Insect growth regulators (IGRs)

Predators and parasitoids

Baculovirus (SoNPV)

Non-spore forming bacteria (*Bt*)

Neem products

Figure - 13: Possible IPM methods for the control of *S. obliqua*
& Btk have been carried out against the larvae of *S. obliqua*. The results obtained in the above studies are promising that they can be used for the control of *S. obliqua*. On the basis of the field studies on parasitoids and laboratory bioassay on microbials, the following agents can be tried for the field control of *S. obliqua* (Figure –13).