Chapter 4

Discussion

Discussion
The present study was undertaken with an objective to find ways to control insect pests of sesame, an important oil seed crop of great economic importance for the country. This was attempted by using some natural and indigenous products (Neem oil, Neem seed kernel extract, Neem leaf extract, Cow urine, Cow butter milk and admixture of Garlic and Red pepper), and a bio-agent (*Bacillus thuringiensis* Dipel) comparing the effects with those of a known natural product (commercially available as Neem oil) and a commonly used insecticide (Endosulfan). The plots sown with sesame were treated individually with the compounds, intermittently with one of them or alternately with more of them. Attempts were also made to study effects of intercropping of sesame with some other crops to observe effects on its pests. Bionomics of a major, a minor and a sporadic pest (*Antigastra catalaunalis* Duponchel, *Dasineura sesami* Grover & Prasad and *Acherontia styx* Westwood respectively) of sesame was studied as a pre-requisite for their management by the means mentioned above.

The rationale of the work undertaken was to explore ecofriendly alternative strategies of controlling pests of sesame to avoid the usual practice of using chemical insecticides which have detrimental effects on the environment. After a rigorous study of three years (2004-'06) the objective has been well achieved and very good results have been obtained as discussed in this chapter.

The present work is a novel approach from the point of view of the following aspects, which have not been studied before or not explored elaborately, so far as I know from a thorough survey of literature on the relevant subject.

- Detailed study of bionomics of *Dasineura sesami* Grover & Prasad, which was reported way back in 1966 by Grover & Prasad and then in 1967 by Prasad. The only recent study on life span of this species is by Rai et al., (2001).
- Detailed study of bionomics of *Acherontia styx* Westwood. It was reported way back in 1847 by Westwood and then after a long lapse of time in 1962 by Mukherji. Life span of this insect was recently studied by a few workers (Mehta and Verma, 1968; Lefroy, 1990; Rai *et al.*, 2001; Sharma and Choudhary, 2005; Atwal and Dhaliwal, 2005).

- Management of *Antigastra catalaunalis* and *Dasineura sesami* have been attempted by individual sprays of natural and indigenous products, sprays of admixture of garlic buds and red peppers, cow urine and cow butter milk, the later three being traditionally used by farmers (Annual Report of ICAR 2003, '04, '05, '06; Gupta 2007).

- Management of these pests by alternate/intermittent sprays of bio-agent and natural and indigenous products like *Bacillus thuringiensis* Dipel, Neem seed kernel extract and Cow butter milk respectively. Results of the only previous work on this line are by Jani *et al.*, (2001) and those given in ICAR Annual Report (2004, '05, '06).

- Management of sucking pests (jassid, *Orosius albicinctus* Dist., mirid bug, *Nesidiocoris tenuis* Rent. and whitefly, *Bemisia tabaci* Gen.), which are major and minor pests of sesame plants. Studies on management of jassid and whitefly have been recently done by Dar *et al.*, (2001); Gupta *et al.*, (2001); Kumar *et al.*, (2006); Jat and Jeyakumar (2006); Gupta and Pathak (2007) on mungbean, sesame, mungbean, cotton and black gram respectively.

- Yield attributes of sesame (plant heights in cm, number of branches and that of capsules) and grain yield as an impact of treatment with compounds mentioned earlier as well as by intercropping. The only previous work on yield attributes and grain yield is by intercropping and planting geometry as

Life cycle of the major pest of sesame *Antigastra catalaunalis* Duponchel has been studied since long by many workers viz. Menon et al., (1960), Teotio and Hussain (1965), Desai and Patel (1965), Mehta and Verma (1968), Mohamed (1976), Cheema (1981), Cheema and Singh (1987), Patidar (1988), Hill (1993), Ahuja and Bakhetia (1995), Kumar and Goel (1997), Ahuja et al. (2000), Selvendarayanan and Baskaran (2000), Rai et al., (2001), Singh (2002), Singh (2003), Atwal and Dhaliwal (2005), Sharma and Choudhary (2005) and is also reported in the Annual Report of ICAR, 1995. Some of the above authors have reported damage caused by this moth to sesame crop. However, a much more detailed study on the bionomics of this pest as well as damage caused to different parts of sesame crop by it has been done in the present work. It has been found that *Antigastra catalaunalis* completes its life span in 28 days. Third, fourth and fifth larval stages are voracious feeders of leaves/flowers/capsules, so much so that even one to three larvae are enough to denude a fully grown plant within 24 to 48 hrs.

One of the minor pests of sesame – *Dasineura sesami* Grover & Prasad has been found to have a life span of 18-33 days. The second, third and fourth larval stages are voracious feeders of flowers and damage the plants within one to four days. These observations are in close agreement to studies of Rai et al., (2001). The bionomics of other species viz. *Dasineura lini* and *Dasineura oxycoecana* are studied by Atwal and Dhaliwal (2005) and Yang (2005).

Treatments as described under ‘Materials and Methods’ and tabulated under ‘Results’, were given at the time of maximum attack when the plant age was normally 25 to 35 days. For management
studies, in case of *Antigastra catalaunalis* and *Dasineura sesami*, effect of sprays were observed from this period onwards.

A sporadic pest of sesame crop – *Acherontia styx* Westwood has been found to complete its life span in 39 days. The third, fourth and fifth larval stages are very harmful to the plant. This pest is voracious feeder of leaves/branches/flowers/capsules and almost entire plant is denuded by one larva within 24 hrs. Bionomics of this pest has been studied by Mehta and Verma (1968), Lefroy (1990), Rai *et al.*, (2001), Sharma and Choudhary (2005) and Atwal and Dhaliwal (2005). Bionomics of other species like *Acherontia atropos* has been studied by Hill (1993). However, a much more detailed study has been done in the present work.

Management studies in the present work have been done using individual sprays of compounds mentioned in Materials and Methods’ in separate plots, alternate and intermittent sprays in the same plots and intercropping on sesame with pigeon and black gram, Cluster bean, Sorghum and Pearl millet. In addition to management of *Antigastra* and *Dasineura*, that of *A. styx*, mirid bug and whitefly – which infest sesame plants during different periods of the season – has also been studied.

Larval population of *Antigastra* and *Dasineura* and also nymph and adult populations of sucking pests viz. jassid, mirid bug and whitefly were significantly controlled by two individual sprays of natural products such as Neem oil, Neem seed kernel extract, Neem leaf extract and admixtures of Garlic bud & Red pepper. Similarly, two individual sprays of indigenous products such as Cow urine and Cow butter milk as well as the chemical pesticide Endosulfan were also significantly effective. The effectiveness of these compounds have been found to be in the order of, Endosulfan > Neem seed kernel extract (in cow urine) > Neem oil > Neem leaf extract (in cow
Discussion

urine) > Garlic buds + Red pepper extract @ 10 ml/l > Cow urine > Garlic buds + Red pepper extract @ 5 ml/l > Cow butter milk.

These results are similar as described by Gupta et al. (2005) except that they have used only one concentration of Garlic buds + Red pepper extract (0.5%) and have not reported about Cow butter milk.

According to Gupta et al., (1999, 2000) larval population of Antigastra catalaunialis were significantly reduced by Neem oil followed by Endosulfan. Gupta in 2001, again showed positive effects of two other neem products i.e. leaf and kernel extract on this insect, the former at 5% concentration. Such results have been also confirmed by Nath et al., (2002) and Bhanukiran and Panwar (2002).

According to Muralibaskaran et al., (1993) and Duhoon (2003) population of Antigastra larvae was reduced by Endosulfan and Neem oil. They have also reported effects of ‘Neem gold’ and ‘Nimbicidin’, which are commercially available.

My results on control of Dasineura larval population are in conformity with those of Malik et al. (1996), Gupta et al., (2001), Nath et al., (2002), Tomar et al., (2003) and Gupta and Rawat (2004) so far as the effect of Neem oil, Neem seed kernel extract and Neem leaf extract is concerned, except sometimes the order of efficacy of the compounds as described under ‘Results’. Gupta et al., (2000) have reported that maggot population of bud fly, Dasineura sesami was found to be minimum with Neem oil 1% followed by Neem oil 0.5%.

According to Dar et al., (2001) NSKE 5% was found effective in reducing the population of both jassids and whiteflies in mungbean. However, Endosulfan 0.07% ranked first in reducing these populations as also found in the present study. Gupta et al., (2001) observed that NSKE and Neem oil were equally effective and
The neem based insecticides viz. NSKE (0.3%), Achook (0.3%), Neem gold (0.3%) and Nimbicidin (0.3%) were found comparable to Monocrotophos and Dimethoate against whitefly in mungbean (Kumar et al., 2006).

According to Jat and Jeyakumar (2006) Neem oil was more effective against jassids than NSKE. However, both Neem oil and Neem seed kernel extract were found to reduce more than 50% of whitefly population in cotton, as has also been observed in the present work on sesame.

Gupta and Pathak (2007) reported that the admixture of NSKE (in cow urine) + Dimethoate and Neem oil + Dimethoate not only reduce the incidence of whitefly and yellow mosaic virus but also the pod borer on black gram.

Positive and significant results have been obtained in the present study by alternate and intermittent treatment of plots sown with sesame, with the compounds mentioned earlier. Larval population of Antigastra & Dasineura, nymph and adult population of jassid, mirid bug and whitefly were significantly reduced by alternate/intermittent sprays of Neem seed kernel extract (NSKE), Bacillus thuringiensis Dipel (Bt-Dipel), Cow butter milk (CBM) and Endosulfan. The order of effectiveness of the compounds has been usually found to be, Endosulfan (four intermittent sprays) followed by Neem seed kernel extract (in water) (four intermittent sprays), NSKE / Bt-Dipel / NSKE / Endosulfan (alternate sprays), NSKE / Endosulfan / NSKE / Endosulfan (alternate sprays), Bt-Dipel / NSKE / Endosulfan / NSKE (alternate sprays) and Cow butter milk (four intermittent sprays).

Jani et al (2001) has done similar work on pod borer complex in pigeon pea and have found that the larval population was...
significantly minimum with *Bt*-HaNPV-*Bt*-HaNPV (four alternate sprays) and Endosulfan (three intermittent sprays) followed by Endosulfan-*Bt*-HaNPV-*Bt*. No other literature has been found on management of other pests by these methods. Similarly, no literature is available, so far as the author is aware, on effect of alternate or intermittent sprays of insecticides, natural products or other compounds on control of population of sucking pests of sesame.

Results obtained by intercropping sesame with other crops show that population of *Antigastra catalaunalis* and *Dasineura sesami* larvae were significantly reduced. The order of efficacy derived from the present results is, intercropping with Green gram followed by that with Black gram, Cluster bean, Sorghum and Pearl millet. No work has been done on effect of intercropping on larval population of *Dasineura* so far as the author is aware.

My observations are in conformity with those of Gupta and Chourasia (2004) who have intercropped sesame with Pigeon pea, Lathara, Black and Green gram, Groundnut and Soybean for management of *Antigastra* larval infestation. According to ICAR Annual Report (1996, '97) larval population of *Antigastra catalaunalis* were minimum when sesame was intercropped with Lathara, Arhar, Black gram, Green gram, Groundnut and Soybean. Manisegaran et al., (2000) reported that when sesame was intercropped with Groundnut VRI 2 or Pearl millet CO 6 or Black gram T9 at 4:1 ratio, the incidence of leaf roller on sesame TMV 3 was reduced.

Per cent damage of leaves/flowers/capsules caused by *Antigastra* and *Dasineura* larvae were significantly reduced by Endosulfan followed by Neem seed kernel extract, Neem oil and Neem leaf extract (all in cow urine). Garlic buds + Red pepper extract act significantly, but is less effective than neem products. Out of the two indigenous products, Cow urine is more effective than Cow butter milk.
Thus, my results are in conformity with those of Singh and Singh (1997); Manisegaran et al., (1998); Gupta et al., (1999); Gupta (2001, '03); Gupta et al., (2005) and ICAR Annual Reports (2004, '05, '06) - so far as effect of Endosulfan, Neem seed kernel extract (aqueous), Neem oil, Neem leaf extract, Neem kernel extract (in cow urine), Garlic buds + Red pepper extract @ 10 & 5 ml/l on per cent damage of leaves/flowers/capsules caused by Antigastra and Dasineura larvae is concerned.

Gupta (2007) observed that the per cent pod damage caused by gram pod borer, Helicoverpa armigera was significantly controlled by Cow butter milk (8%), Bt Halt (0.2%), Garlic buds + Red pepper extract (1:1-1%), Garlic buds + Red pepper extract (1:1-2%), NSKE (in cow urine 3% + Cypermethrin-0.01%) in chickpea. However, Cow butter milk has been found to be the least effective in the present work with sesame pests.

My observations on per cent damage of flower and capsule caused by Dasineura sesami differ than those of Gupta et al., (2000) and Gupta and Rawat (2004) on the effect of Neem oil (1% and 0.5%), Neem kernel extract (aqueous 2%), Neem kernel extract (in cow urine 2% and 3%), and Neem leaf extract (in cow urine-3%) on the same aspects in another species of Dasineura i.e. Dasineura lini.

Per cent damage of leaves, flowers and capsules caused by Antigastra and Dasineura larvae were significantly reduced by Endosulfan (four intermittent sprays) followed by Neem seed kernel extract (in water, four intermittent sprays), NSKE / Bt-Dipel / NSKE / Endosulfan (alternate sprays), NSKE / Endosulfan / NSKE / Endosulfan (alternate sprays), Bt-Dipel / NSKE / Endosulfan / NSKE (alternate sprays) and Cow butter milk (four intermittent sprays).

Results published in ICAR Annual Report (2004, '05, '06) for control of damage of leaves, flowers and capsules by Antigastra and
**Discussion**

*Dasineura* larvae by intermittent sprays of Endosulfan, NSKE and CBM and alternate sprays of NSKE either with Endosulfan or *Bt*-Dipel, support the observations obtained in the present work. Jani *et al.* (2001) have reported positive effect of alternate treatment of plots with *Bt*-HaNPV- *Bt*-HaNPV, Endosulfan, Endosulfan-*Bt*-HaNPV- *Bt* and intermittent sprays of Endosulfan on per cent seed damage caused by pod borer complex in pigeon pea.

Per cent damage of leaves, flowers and capsules caused by *Antigastra catalaunalis* and *Dasineura sesami* larvae were significantly controlled by intercropping system. The order of efficacy derived from the present result is, intercropping with Green gram followed by that with Black gram, Cluster bean, Sorghum and Pearl millet. ICAR Annual Report (1995) mentioned that per cent damage of leaves, flowers and capsules caused by *Antigastra* larvae were significantly reduced when sesame was intercropped with other crops like Combu, Black & Green gram, Groundnut etc. The results mentioned in ICAR Annual Report (2005, '06) also support my results as regards effect of intercropping of sesame with both the gram crops, Cluster bean, Sorghum and Pearl millet on flower damage caused by *Antigastra* larvae is concerned. No work has been done on effect of intercropping on per cent flower damage caused by *Dasineura* larvae so far as the author is aware.

According to Murali Baskaran *et al.*, (1991), pest infestation was reduced in sesame when it was intercropped. According to them, sesame as sole crop showed significantly higher infestation (23%) by *Antigastra* larvae in comparison with sesame intercropped with Pearl millet and Groundnut, showing incidence of 7.8 and 12% respectively, followed by farmers' method of intercropping with Pearl millet (14.2%), Green gram (15.1%) and Black gram (16.3%).

No work has been done, so far as the author is aware, on the yield attributes (plant heights in cm, number of branches and
capsules) of sesame or any other crop as an effect of treatment with any of the above compounds. In the present work yield attributes have been found to increase significantly after individual treatment (spray) with the compounds already mentioned. The order of efficacy has been obtained as, Endosulfan > Neem seed kernel extract (in cow urine) > Neem oil > Neem leaf extract (in cow urine) > Garlic buds + Red pepper extract @ 10 ml/l > Cow urine > Garlic buds + Red pepper extract @ 5 ml/l > Cow butter milk.

Yield attributes were also significantly increased by intermittent and alternate treatment of plots. The following order of efficacy has been derived - Endosulfan (four intermittent sprays) followed by Neem seed kernel extract (in water) (four intermittent sprays) > NSKE / Bt-Dipel / NSKE / Endosulfan (alternate sprays) > NSKE / Endosulfan / NSKE / Endosulfan (alternate sprays) > Bt-Dipel / NSKE / Endosulfan / NSKE (alternate sprays) > Cow butter milk (four intermittent sprays). However no work has been done on yield attributes, as mentioned above, using the above or any other method.

The yield attributes significantly increased when sesame was intercropped with Green gram followed by Black gram, Cluster bean, Sorghum and Pearl millet. According to Krishna and Reddy (2005), the plant height and number of branches were higher when sesame was intercropped with Green gram (100%) in single row single skip.

The grain yield, net profit and incremental cost benefit ratio (ICBR) were significantly increased by two individual sprays of the five natural products, the two indigenous products and the chemical insecticide Endosulfan in all plots. The effectiveness of these compounds has been found in the order of Endosulfan > Neem seed kernel extract (in cow urine) > Neem oil > Neem leaf extract (in cow urine) > Garlic buds + Red pepper extract @ 10 ml/l > Cow urine > Garlic buds + Red pepper extract @ 5 ml/l > Cow butter milk so far
as grain yield and net profit are concerned. However, ICBR was always the highest in Neem seed kernel extract treated plots followed by Neem leaf extracts, Cow urine and Endosulfan treated plots.

Thus, my results are in conformity with those of Muralibaskaran et al., (1993); Singh and Singh (1997); Manisegaran et al., (1998) and ICAR Annual Reports (2003, '04, '05, '06) so far as effects of Endosulfan, Neem seed kernel extract, Neem oil, Neem leaf extract, Garlic bud + Red pepper extract, (1:1) @ 10 ml/l, Cow urine on grain yield of sesame are concerned.

Gupta et al., (1999, 2000) and Gupta (2001, '03) reported that the grain yield was the highest with Neem oil treatment followed by Neemax and Endosulfan, Neem kernel extract and Neem leaf extract treatments. Maximum net profit and benefit: cost (B: C) ratio were achieved with Neem oil followed by Neemax, Endosulfan, Neem kernel extract and Neem leaf extract.

My observations differ than those of Gupta et al., (2000) on the effect of Neem oil 0.5 % & 1% and Dimethoate 0.03% on grain yield, net profit and ICBR. They have shown that grain yield as well as maximum net profit significantly increased in plots treated with Neem oil 0.5% + Dimethoate 0.03% followed by Neem kernel extract 3% + Dimethoate 0.03%, Neem oil 0.5% + Methyl demeton 0.03%. ICBR was highest with Neem oil 0.5% + Dimethoate 0.03% than that with Neem kernel extract 3% + Dimethoate 0.03% and Neem leaf extract 3% + Dimethoate 0.03% in linseed. Obviously, the difference from my results is due to the fact that Methyl demeton and Methyl dimethoate have been admixedtured with Neem kernel extract and Neem oil by the authors named above.

According to Gupta et al., (2005) grain yield, net profit and ICBR significantly increased by treatment with Neem kernel extract (in cow urine) followed by Neem leaf extract (in cow urine),
Endosulfan, Garlic buds + Red pepper extract @ 0.5%, Neem oil and Cow butter milk, as has also been observed in the present work.

Many authors like Gupta (2005, '07); Gupta and Rai (2006); Gupta and Pathak (2007) have reported that grain yield, net profit and ICBR significantly increased by Phosphamidon 0.04%, Neem oil 1% + Dimethoate 0.03%, Neem kernel extract 2%, Neem leaf extract 3%, Neem kernel extract 3% + Dimethoate 0.03%, Neem kernel extract (in cow urine), Neem leaf extract (in cow urine), Cypermethrin, Quinolphos, Neem seed kernel extract (in cow urine) + Cypermethrin, Garlic + Red pepper extract (1:1) -1%, NSKE (in cow urine) 3% + Bt - 0.2%, G + RPE 0.5%, CBM - 4%, NSKE (in cow urine) 3% + Dimethoate 0.03% and Neem oil 0.5% + Dimethoate - 0.03% in managing the pests of mustard, chickpea and black gram crops respectively.

So far as intermittent and alternate sprays of the compounds in the present study is concerned, grain yield was maximum in the plots treated with Endosulfan (four intermittent sprays) followed by those with NSKE (aqueous, four intermittent sprays), NSKE / Bt-Dipel / NSKE / Endosulfan > NSKE / Endosulfan / NSKE / Endosulfan > Bt-Dipel / NSKE / Endosulfan / NSKE (alternate sprays) > Cow butter milk (four intermittent sprays). However, net profit and ICBR was the highest in Neem seed kernel extract treated plots.

Thus, NSKE was the best option for insect pest management as an alternative to the chemical insecticide Endosulfan, as derived from the present work.

The above results are in conformity with the reports of ICAR Annual Report (2004, '05, '06) so far as effect of NSKE / Bt-Dipel / NSKE / Endosulfan, Bt-Dipel / NSKE / Endosulfan / NSKE, NSKE / Endosulfan / NSKE / Endosulfan (all alternate sprays), NSKE, CBM
and Endosulfan (all intermittent sprays) on grain yield, net profit and ICBR is concerned.

The base crop and seed equivalent grain yield (kg / ha) were maximum when sesame was intercropped with Green gram than when it was intercropped with Black gram. However, intercropped grain yield was maximum when sesame was intercropped with Sorghum, Pearl millet and Green gram.

Thus, the results reported by Sharma and Kakati (1991); Tiwari et al., (1994); Behera et al., (1994); Hosmath and Patil (1999); Shrivastava et al., (2000); Gupta and Chourasia (2004) support my work so far as the effect of Sesame + Green gram and Sesame + Black gram intercropping systems on seed equivalent grain yield is considered.

Muralibaskaran et al., (1991) reported that the yield of sesame was highest when it was intercropped with Groundnut followed by Green gram under farmer method. Sesame yield was at par when grown along with Groundnut in line sowing followed by Sesame + Pearl millet intercropping. However, the yield was much more when sesame was sown alone.

According to Annual Report of ICAR (1995, ’96, ’97) the seed equivalent grain yield was registered the highest when sesame was intercropped with Black gram (4:1) than with all other crops under study such as Groundnut, Cumbu, Green gram, Arhar, Sorghum etc. as well as Black gram in a different ratios such as 6:1.

My observations differ than the reports of ICAR Annual Report (2005, ’06) on the effect of intercropping system of Sesame + Black gram, Sesame + Cluster bean, Sesame + Sorghum, Sesame + Green gram, Sesame + Sorghum, Sesame + Pearl millet on seed equivalent grain yield. This is because, in the present study the seed equivalent grain yield was highest when sesame was intercropped with Green gram followed by Black gram.
Thus, the different results tabulated, described and discussed here, on larval population of *Antigastra & Dasineura*, nymph & adult population of jassid, mirid bug and whitefly, per cent damage of leaves/flowers/capsules and grain yield/economics have led to the conclusion that although Endosulfan is most effective, it is invariably followed by NSKE for the various parameters tested as above. In some case it is equally good as the insecticide in controlling the pests and ultimately resulting in better yields. Hence, it is suggested that the chemical insecticide Endosulfan can be replaced successfully by the natural product such as Neem seed kernel extract which is ecologically safe as well as economical. Neem oil and Neem leaf extract are also good agents for management of insect pests. As the pests mentioned above are also successfully controlled by intercropping system, the farmers can also be suggested to use Green gram and Black gram crops for intercropping with sesame to manage most of its insect pests.

The crop protection market is still dominated by conventional chemical control methods. However, new agrochemicals of natural origin, with active compounds, are continuously being looked for and are needed either to be used alone or along with classical chemical and other approaches for integrated crop management. The present work has been an attempt well fulfilled in this direction.

While carrying out the experiments for control of pests of sesame some adult predators were found such as *Agathis* species, *Chrysoperla carnea* (Stephens) and *Carabid grub*. These were found praying upon the larvae, pupae and adults of different pests at different periods of development as shown in the Fig. 99 a to 99 f. It is proposed to carry on this work further considering the aspect of predation as a control measure for pests of sesame for Insect Pest Management (IPM).
Fig. 99: (a) Cocoon of *Agathis* sp. (b) Male and female of *Agathis* sp. (adults): larval-pupal parasite (c) *Chrysoperla carnea* (stephens) (adult): larval-pupal predator (d) *Carabid grub* (adult): larval, pupal and adult predator (e, f) Carabid grub predating on larva and adult of *Antigastra catalaunalis* Duponchel