DISCUSSION

Phytophagous insect species make up over one quarter of all living organisms, and that the green plants upon which they feed makes up another quarter. The plant surface, with its enormous varieties of niches, not only enabled the insects to move away from the soil surface, but also offered an ideal habitat for their life cycles (Southwood, 1986). For an insect, the host plant is not merely something to feed on but also something to live on. A host is one on which an insect completes its growth and developments and can produce its progeny successfully.

The ability of the phytophagous insects to utilize plant tissue for energy, growth and reproduction has made them agents of serious economic losses in agricultural productivity. At present, crop losses to pests from different phylum, are estimated to be about 37% globally out of which insect’s share alone accounts of 13% (Gatehouse et al., 1992). Agriculture in the present scenario played a crucial role in the developmental of human civilization. Modern agricultural practices, such as use of fertilizers and pesticides, selective breeding and mechanization the agricultural practices in past century sometimes aggregate the pest problems. Agriculture has not only experienced the green revolution in recent past, but also experienced some of the most harmful agricultural pests.

Many of the world’s devastating insect pests belongs to order Lepidoptera, amongst which Spilosoma obliqua is a one of the most destructive, commonly known as Bihar hairy caterpillar, is a polyphagous insect pest which attacks nearly 126 plants species distributed in 24 families (Singh and Varathrajan, 1999), and cause extensive damage to many crops such as oilseeds, pulses, vegetables, fodder, fibre crops, fruit trees.
etc (Sethi, 1979; Singh and Singh, 1992). Menace of this pest is has been continuously increasing in recent past (Deshmukh et al., 1976). The population of this insect often reaches epidemic level when they defoliate plants and move from field to field finishing the vegetation of the area of their visit (Singh and Bhattacharya, 1994).

Indian farmers have been relying heavily on synthetic insecticides to control this pest, because of their easy availability, economy and quick knockdown effect. However, continuous and indiscriminate use of insecticides over the years has resulted in the development of resistance against different classes of insecticides in different parts of the world.

As synthetic insecticides are known to have wide spread toxicity, this leads to the search for a suitable alternative natural products. The plant kingdom is by far the most efficient ‘factory’ of chemical compounds, synthesizing many products that are used against herbivores (Schoonhoven et al., 1998). Plants extracts consist of complex mixtures which are sustainable and does not cause harm to the environment. Advantages of using complex mixtures as pest control agents are that natural mixtures (Berenbaum, 1985) or they may higher bioactivity as compared to the individual constituents. Moreover, they act synergistically and are less likely to develop resistance against it (Feng and Isman, 1995). Compounds rather than the use these insecticides has extended into many different plant families, including the Meliaceae. The chinaberry tree, *Melia azedarach* L. has been reported to exhibit various anti-insect activities against many agricultural pests from different orders. *Melia* in particular has shown great potential for pest management in terms of secondary plant chemistry or the presence of
allelochemicals in various species (Koul et al., 2002). The main active ingredients in this plant are limonoids.

The bio-efficacy of *M. azedarach* has long been realized for its insecticidal properties. Limonoids from this plant are known to exhibit insect antifeedance, oviposition repellency and insect growth regulatory effect (Carpinella et al., 2002, 2003). Oviposition deterrent and repellent activity of *M. azedarach* fruit extracts have also been reported on diamondback moth, *Plutella xylostella* Chen et al., (1996a) and *Bemisia tabaci* (Hammad et al., 2001) and gram pod borer, *Helicoverpa armigera* (Koul et al., 2002). Akhtar and Isman (2003) found marked growth inhibition efficacy in *M. volkansii* crude extract against *Trichoplusia ni* and *Pseudalita unipancta*. Therefore, based on the previous literature, the present study was conducted to assess the impact of *M. azedarach* on biology of *S. obliqua* in laboratory conditions.

*M. azedarach* have gain much of interest for their insecticidal activity and other insect controlling properties. A wide range of bioactive compounds, of *M. azedarach* have shown insecticidal activity and out of them limonoids were found to be most active compounds (Oelrichs et al., 1983; Carpinella et al., 2003).

In the present study of insecticidal bioassay on neonate larvae of *S. obliqua*, suggested that among *M. azedarach* fruits extracts acetone fraction of methanol extract (AFME) contain compounds that possess toxic properties against *S. obliqua* larvae, and has adverse effects on the survival of *S. obliqua* larvae as compared to methanol fraction of methanol extract (MFME). The larvicidal effect of polar extracts of *M. azedarach* was not exhibited for short duration feeding. However, exposure of larvae for longer duration to this extract had significant effect on the survival of larvae. Mortality may be due to
gradual accumulation of toxins in the body of larvae that fed for longer duration (Miller and Miller, 1988). Similar effect of methanol extracts of *M. azedarach* on *Locusta migratoria* was also reported by Wen and Schmutterer (1991). They found increased mortality of insect both due to increase in concentration and duration of exposure. 100% mortality in 3rd instar larvae of *Agrotis ipsilon* and *Spodoptera littoralis* larvae when they were fed diet incorporated with methanolic extract of *M. azedarach* (Schmidt et al., 1997).

Dose dependent activity of polar extracts in the present study, which is similar to the findings of Mitchell *et al.*, (2004). They observed mortality rate of *Nezara viridula* nymphal instars increased with the concentration of ethanolic fruit extracts of *M. volkansii*. Nathala and Dhingra (2005) also recorded lethal effect of methanol extract of *M. azedarach* seeds against *H. armigera* larvae when fed for the longer duration. The possible explanation for this effect might be presence of mixture of compounds in the methanol sequential crude extract, which may act synergistically to enhance the bioefficacy of extracts, when fed for longer duration (Laetemia and Isman, 2004). Toxic effects of *M. azedarach* has also been reported against *Spodoptera frugiperda* (Breuer and Schmidt, 1990, 1995 and 1996).

*M. azedarach* has been observed to cause adversely affect growth, which is significantly prolonged development of larvae. This was more acute for non polar fraction of extract. Similar antibiotic effect of *M. azedarach* extracts has also been reported against Elm leaf beetle, *Xenthogalleruca luteola* (Valladares *et al*. 1997), teak defoliator *Hyblaea puera* (Nathan and Sehoon, 2006) and *Spodoptera frugiperda* (Vasakorn, *et al*., 2011). These observations clearly indicate that *M. azedarach* has
antibiotic component that interfere with physiology of insect. This antibiotic effect is more pronounced when larvae are young as compared to old. Acetone fraction of extract had adverse effect on the pupation of *S. obliqua* which indicate that these extract cause hormonal imbalances which interfere with moulting from larvae to pupae. This imbalance was also responsible for larval-pupal intermediary, deformed pupae and emergence of abnormal adults retaining pupal case. This may also be due to the presence of growth inhibitory compounds in *M. azedarach*. Present results support the previous reports of insect growth regulatory activities of *M. azedarach* against *L. huidobrensis*, (Hammad *et al.*, 2000). The present findings indicated the presence of secondary compounds in *M. azedarach* that is responsible for reduced growth and moulting disruption.

Feeding is the most critical stage, in the process of host plant selection, which determines the establishment of an insect population on a food plant. The plant factors mediating insect responses of phytophagous insect comprise a complex combination of physical and chemical factors of the plant. These specific phytochemical guide the insects either to accept or reject a particular plant species (Hsiao and Fraenkel, 1968). Feeding not only affects growth, development and survival of the larvae, but also affects fecundity, mating success and vigour of moths.

Feeding response of *S. obliqua* larvae indicated the presence of feeding deterrent compounds in the acetone fraction of *M. azedarach* extract. The inhibition may be due to presence of feeding deterrent in the extract, which ultimately affects consumption and growth of larvae. Moreover, presence of deterrence in acetone fraction of extract is evident from antifeedant index (AFI) value of AFME, which may be due to presence of meliartinin and/or toosendanin in the acetone fraction.
Presence of feeding deterrent in crude *Melia* extracts was also reported against important agricultural pests (Akhter and Isman 2004), including *Sesamia nonagrioides*, (Juan *et al.*, 2000) and *Helicoverpa armigera* (Nathala and Dhingra, 2005). Strong feeding inhibitory effect of *M. azedarach* fruit extracts has been reported against larvae and adults of *Xanthogalleruca luteola* (Valladares *et al.*, 1997) and *Liriomyza huidobrensis* (Banchio *et al.*, 2003). Observation of reduced fecal count in the present study reflects strong feeding inhibition. This has also been reported for this extract against *A. ipsilon* and *S. littoralis* (Schmidt *et al.*, 1997).

*M. azedarach* extracts incorporated diet had detrimental effect on the larvae, which is reflected by reduced consumption index (CI) and growth rate (GR). However, increase approximate digestibility (AD) may be due to increase in the absorption rate of food in the insect gut to compensate for the reduced consumption and utilization of food. High AD on *M. azedarach* may be due to greater retention of food in the midgut to overcome the nutritional demand (Mordue *et al.*, 1985; Trumn and Dorn, 2000).

Efficacy of conversion of ingested food (ECI) and digested food (ECD) are indicator for conversion of ingested food in biomass and ability of the insect to ingest the food for growth. The decreased rate of ECI and ECD along with reduced CI, RGR and increased AD for polar extract of *M. azedarach in S. obliqua* reflect chronic toxicity of extract. This results corroborate the finding of Schmidt *et al.*, (1997), they observed similar effect of extract against *A. ipsilon* and *S. litura*. They suggested on the basis of histological studies that was due to degeneration of gut epithelial cells. Similar effect of *M. azedarach* fruit extracts on food consumption, digestion, relative consumption rate
(RCR), gross dietary utilization (efficiency of conversion of ingested (ECI) and digested (ECD) was also reported by Nathan and Sehoon (2006).

Oviposition is an important step, which determines the next generation of a particular insect pest. Information about oviposition deterrent may be useful for insect pest management. Oviposition response of S. obliqua female showed reduction in egg deposition on M. azedarach extract treated leaf. This is reflected by oviposition deterrence index. There are similar reports on chinaberry extracts causing ovipositional deterrence in Plutella xylostella (Chen et al., 1996a), Earias vitella (Gajmer et al., 2002) and Bemisia tabaci (Hammad et al., 2001).

Effect of M. azedarach extracts on the S. obliqua eggs was observed in terms of hatchability. Such ovicidal activity of Melia extract has also been reported on stored grain insects, the rusty grain beetle, C. ferrugineus, the rice weevil, S. oryzae and red flour beetle, T. castanum (Xie et al., 1995).

In the present study, acetone fraction of M. azedarach extract showed strong feeding deterrence against S. obliqua larvae. Such feeding deterrency of M. azedarach fruit extract has also been reported against Aulacophora foveicollis (Khan and Wasim, 2001), Bemisia tabaci (Hammad et al., 2001). Akhtar and Isman (2003) also recorded repellency of crude extracts of M. volkansii against cabbage looper (Trichoplusia ni), armyworm (Pseudalelia unipuncta), diamondback moth (Plutella xylostella), and maxima bean beetle (Epilachna varivatis).

M. azedarach in particular has shown great potential for pest management in terms of secondary plant chemistry or the presence of allelochemicals in its various allied species. It is native to Northwestern India and has long been recognized for its
insecticidal properties. This plant currently grows in number of countries including Africa Australia and the Americas. Understanding the importance of *M. azedarach*, can be an effective tool in insect pest management where a number of management methods have been combined together for effective and sustainable control of insect pests. Biological control is one such strategies provide a natural control technique. However, because of non-judicious use synthetic pesticides has adversely affected this tri-trophic interaction, and as such biological control alone is insufficient to provide adequate protection, and requires integration with other control techniques.

This has been reported that neem and melia derived botanicals are helpful both in bottom regulation and top down regulation. Bottom up regulation is achieved by adversely affecting the physiology of insect pest thus restricting its development, growth and reproduction and promoting mortality. Top down regulation is achieved as it has been reported in many cases that *Melia* derived botanicals promotes the efficacy of natural controlling agent for e.g., *Cotesia plutellae*, the parasitoid of *P. xylostella*, serious pest of cruciferous plant (Charleston, 2004). Similar observation were reported for the natural controlling agents of *H. armigera* (Ma et al., 2000) and *B. tabaci* (Jazzar and Hammad, 2003).

Results obtained in the present investigation indicated the antibiotic effect of *M. azedarach* against *S. obliqua*. The phytochemicals presents in the fruits of this tree adversely affect biology of this insect, which put pressure on the growth of population. However, it requires more detailed study to isolate and identify chemical responsible for such actions that can be used more effectively and efficiently for the management of *S. obliqua*. 