STUDY ON BIOLOGY AND EFFECTIVENESS OF SOME CHEMICAL INSECTICIDES AGAINST JUTE HAIRY CATERPILLAR, *SPILOSOMA OBLIQUA* (WALKER)

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CERTIFICATE

This is to certify that thesis entitled **"STUDY ON BIOLOGY AND EFFECTIVNESS OF SOME CHEMICAL INSECTICIDES AGAINST JUTE HAIRY CATERPILLAR, *SPILOSOMA OBLIQUA (WALKER)*"** submitted to the **Faculty of Agriculture,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. MEZBAH UR RAHMAN, Registration no. 11-04512** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: DECEMBER, 2017
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SAU, Dhaka

STUDY ON BIOLOGY AND EFFECTIVNESS OF SOME CHEMICAL INSECTICIDES AGAINST JUTE HAIRY CATERPILLAR, *Spilosoma obliqua* (WALKER)

MEZBAH UR RAHMAN

ABSTRACT

Study on biology of jute hairy caterpillar, *Spilosoma obliqua* (walker) and insecticidal tests were made in the laboratory and in the field of Central station, Bangladesh Jute Research Institute (BJRI), Dhaka and JAES, Manikganj during March to September, 2017. The study revealed that the incubation period was 5.5 ± 0.29 day, total larval period of jute hairy caterpillar was 19.91 ± 0.47 days, pupal period 9.83 ± 0.42 days, egg-adult (female) 42.67 ± 0.69 days and egg-adult (male) 38.67 ± 0.75 days. The pre-oviposition and oviposition periods were 1.42 ± 0.15 days and 3.5 ± 0.29 days respectively. The longevity of female and male moths was 7.41 ± 0.34 days and 3.42 ± 0.26 days. Treatment with Quinalphos: Mekalux 25EC gave the best performance with more than 95% mortality followed by Spinosad: Base 45SP. Emacto 5WDG @ 1.5 kg/ha, Fusion @ 500ml/ha, Rescue 6WDG @ 250/ha, Hayron 5EC @ 500ml/ha, Base 45SP @ 250 ml/ha, Perfect 30 WDG @ 100gm/ha and Mekalux 25EC @ 1.5/ha performed more than 85% mortality of jute hairy caterpillar. All selected doses of insecticides showed more than 80% reduction of plant infestation over control in both two locations Central station, BJRI, Dhaka and JAES, Manikganj. The result of trial in two locations clearly indicated that all the insecticides were effective against jute hairy caterpillar. The application of insecticides had effects on plant height, base diameter and fibre yield of jute in the field.

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LIST OF ABBREVIATIONS AND ACRONYMS

Sl. No.	Abbreviation	Full meaning
1.	a. i.	Active Ingredient
2.	CV	Coefficient of variation
3.	^{o}C	Degree Celsius
4.	Anon	Anonymous
5.	BJRI	Bangladesh Jute Research Institute
6.	*et al.*	and others
7.	etc.	etcetera
8.	EC	Emulsifiable Concentrate
9.	FAO	Food and Agriculture Organization
10.	Fig.	Figure
11.	G	Gram
12.	Ha	Hectare
13.	J.	Journal
14.	JAES	Jute Agriculture Experimental Station
15.	Kg	Kilogram
16.	LSD	Least Significant Difference
17.	m	Meter
18.	mm	Millimeter
19.	^{o}N	Degree North
20.	%	Percent
21.	RH	Relative humidity
22.	RCBD	Randomized Complete Block Design
23.	°S	Degree South
24.	SAU	Sher-e-Bangla Agricultural University
25.	SE	Standard Error
26.	SC	Soluble concentrate
27.	T	Ton
28.	WDG	Wettable dispersible granules
29.	WG	Wettable Granules
30.	WP	Wettable Powder

CHAPTER- I
INTRODUCTION

CHAPTER- I

INTRODUCTION

The genus *Corchorus* belonging to the family Tiliaceae, is commonly known as jute. There are 2 species of jute namely, *Corchorus capsularis* L. and *C. olitorius* L. Jute is mostly grown in Indo-Bangladesh region and in some other countries of the South-east Asia. About 90% of world's jute is produced in Bangladesh and India (Atwal, 1976).

In Bangladesh, about 620.2 thousand hectares of land are under jute cultivation and total production is 1323.1 thousand tons (Anon. 2012). In case of production, it ranks second only after cotton among all the natural fibre (Talukder *et. al.,* 1989). Jute is attacked by various insect and mite pests.

Jute hairy caterpillar (*Spilosoma obliqua*) is the most common and destructive pest of jute. Jute hairy caterpillar, *Spilosoma obliqua* (walker) belongs to the family Arctiidae of lepidoptera order and is a polyphagous insect causing serious damage to a variety of crops (Bhattacharya *et. al.,* 1995).

About 40 species of insects and mites are considered as pests of jute in Bangladesh (Kabir, 1975). Due to their attack the yield is greatly reduced and the quality of fibre is deteriorated. Among the jute pests, *Spilosoma obliqua* (Walker) is the worst one (Sharif, 1962; Alam *et. al.,* 1964; kabir and Khan, 1968).

In Bangladesh, every year jute hairy caterpillar attacks jute crop during the month of May to July and reduces fibre yield by 6-10% depending on the intensity of infestation (Zaman & Kabir, 1990). Larvae of jute hairy caterpillar feed on the jute leaves voraciously and skeletonize them resulting less photosynthesis, less growth and lower fibre yield.

Spilosoma obliqua is commonly known as jute hairy caterpillar/Bihar hairy caterpillar, one of the most serious polyphagous and widely distributed insect pest causing damage to a large number of cultivated as well as non-cultivated plants species (Kabir and Khan, 1969; Deshmukh *et. al.,* 1976; Bhattacharya and Rathore, 1977). Besides Bangladesh, this pest has also been reported from India, Mayanmar, Pakistan, Chaina and many other countries of the world (Kabir and Khan, 1968; Singh and Seghal, 1922).

S. obliqua is a polyphagous but sporadic pest (Nayar *et. al.*, 1976). Although it has been reported from Bangladesh, Myanmar, Pakistan, Philippines and Sri Lanka, its occurrence in India especially in North and North Eastern states is very common particularly during June-September (Nair, 1986; Singh and Sehgal, 1992; Varatharajan *et. al.*, 1998).

As early as 1976, Deshmukh *et. al.,* studied the host range of this caterpillar and observed that it was feeding on nearly 76 plant species. But, now it has become increasingly evident that it is highly polyphagous having a wide host range of as many as 126 species belonging to 24 plant families.

The gregarious feeding habit of early instars and voracious feeding nature of later instars of *S. obliqua* cause appreciable damage to the growing plant. For instance, Singh (1991) reported that the infestation by *S. obliqua* has resulted in the reduction of soybean yield to the extent of 77% in comparison to a healthy plant. Likewise, it inflicts damage to a number of crops particularly, pulse, oilseed and fibre crops like jute etc.

S. obliqua attacks crops throughout the year, the infestation of jute by this pest begins in the month of April, when the plants are about two to three feet in height, but heavy infestation occurs in the month of June-July. The adult female lays eggs in clusters on lower surface of the leaves and after hatching of eggs, the young caterpillars begin to feed on the lower epidermis of the leaves in clusters condition. The early damage of leaves assumes a peculiar membranous appearance. *S. obliqua* larvae pass through six instars (Adsule and Kadak, 1969).

The first and second instars larvae are gregarious having different color patterns greenish yellow to dark orange (Islam and Sardar, 1971). The third, fourth, fifth, sixth instars larvae are dispersed over the entire field. The fifth instar larvae are the most damaging stage (Gaywali, 1988). The whole leaf tissues are eaten up by the caterpillars, leaving only the ribs and the plants may be completely defoliated. If the caterpillars appear in swarm, nothing but bare stems of jute remains in the field (Anon. 1939-40).

Although the caterpillars prefer mature leaves, the top shoots are also eaten up in case of severe attack (Das, 1948). As a result of infestation, the plant growth becomes stunted and the yield is reduced considerably. Hazarika, (1952) reported that jute hairy caterpillar reduced the yield by three mounds of fibre per acre. He further reported that the damage might be as high as 75%. Zaman and Kabir, (1990) reported that 7.3 and 13.2% yield losses by hairy caterpillar were assessed on Tossa and Deshi jute respectively.

Besides jute, this pest also attacks bean, cotton, groundnut, brinjal, cauliflower, radish, linseed, pea, soybean and leguminous crops (Lefroy, 1907; Hazarika, 1952; Kabir, 1966). The host range of this pest is still increasing (Singh and Segal, 1992).

Ahmed and Jalil, (1993) reported that the damage by this pest alone results the reduction in yield by 185-650 kg/ha. Besides jute, it also causes severe damage to a large number of cultivated and wild plant species (Tiwari & Bhattacharya, 1987).

Jute hairy caterpillar can be very injurious unless it is controlled rapidly after its appearance. Chemical control is the last component of Integrated Pest Management programme. Usually, chemical control is an effective control method, especially during the emergency when the insect population exceeds the economic threshold level. There are many synthetic insecticides available in the local market to control jute hairy caterpillar but all are not available in all over the country and all are not equally effective. Moreover, indiscriminate and repeated use of same chemical may lead to development of resistance to target pest. Therefore, more number of chemical pesticides should be included in the recommendation list, which will help overcome the resistance problem of this pest against insecticides.

Furthermore, farmers will have a chance to choose insecticides according to availability and cost. The present investigations were undertaken with the following objectives:

1. To study the biology of jute hairy caterpillar under laboratory condition.
2. To evaluate the efficacy of some insecticides against jute hairy caterpillar in the field.
3. To determine effective and economic doses of these chemical insecticides for the jute growers use.

CHAPTER- II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The jute hairy caterpillar, *Spilosoma obliqua* (Walker) belongs to the order Lepidoptera and family Arctiidae. A review of the literature on the biology of jute hairy caterpillar follows:

2.1 Biology

2.1.1 Life cycle

Information pertaining to different developmental stages of an insect species is a prerequisite for successful management of a pest (Nath & Singh, 1996). Efforts have been made by many workers to study the biology of this pest on some leguminous crops (Singh & Gangrade, 1974; Chaudhary & Bhattarcharya, 1986) the total larval period of six larval stages was 25 days, pupal period was 11 days, male and female longevity being 11 and 9 days respectively. The total life cycle took about 53 days and fecundity per female was about 951 eggs. Its biology was also studied by Nath & Singh, (1996) reported that they laid eggs in parallel rows in cluster on the host leaf with incubation period ranged between 2-9 days but Singh & Gangrade, (1974) reported the incubation period as 6-9 days. Life table statistics of *S. oblique* were also studied by Varatharajan *et. al.*, (1998) on Sunflower and mentioned that egg hatched after 4 days and the total larval period was 28.8 days, pupal period was about 11 days and female laid about 530 eggs and adult female survived for 9 or 10 days under indoor rearing conditions.

Biology of *D. obliqua* was studied by Djou, (1938). He found that a female laid 342-1356 eggs in January, the incubation period was 6-11 days and the larvae development period was 29-38 days. The pupal period lasted for 5-6 days and the males lived for 12-24 days while 14-27 days for female.

Patel, (1940) observed that egg production of *D. obliqua* (Wlk.) was 400-1000 eggs, larval and pupal stages lasted for 6, 14-20, and 9 days, respectively.

Kabir and Khan, (1969) studied Biology of jute hairy caterpillar *Diacrisia obliqua*. They noted that the Arctiid had eight generations in a year. Each generation lasting from 5-8 weeks. The newly hatched larvae fed gregariously for 5 to 6 days, skeletonising the plants and afterwards dispersed and the plant defoliation was complete. Infestation began in the field in April or May and continued for about 3 months. The second and third generation occurred during the jute season are most injurious.

Bhuiyan and Sardar, (1971) experimented the effects of rearing *D. Obliqua* (WIk.) larvae under solitary and crowded conditions (5, 10 and 20 larvae/95.6 cm^3) in the laboratory at 28.9◦C and 85.2***%*** RH. They observed that the duration of larval development averaged about 30, 22, 20 and 20 days respectively for increasing degrees of crowding.

Spilosoma obliqua (Walker) belongs to the family Arctiidae. Members of the Arctiids are mostly tropical with stout body and moderately broad, brightly coloured wings with spots or bands on them. They are nocturnal and capable of producing sound. Long hairs are present on larvae and feed on herbaceous plants. Larval hairs and silk are present on coccon (Nayar *et. al.,* 1976).

Adsule and Kadak, (1979) undertook the binomial studies of *D. obliqua* (Wlk.) on sunflower under laboratory conditions and observed that the female laid pale greenish and spherical eggs in clusters ranging the number 318 to 1830 eggs with an average of 774.62 eggs. The average incubation period was 5.64 days. There were SIX instars within 18- 28 days, the average being 20.86 days. Within silken cocoon, pupation took place and the pupal period lasted for 10 to 18 days. The average longevity of male and female moths was 6.71 and 8.82 days, respectively. They found 36.43 to 46.84 days with an average of 38.55 days in case of total life history.

Banerjee and Haque, (1983) reported that female of *S. obliqua* Walker laid 1009.8 greenish white eggs in clusters. Eggs took 144 - 154 hours for incubation. Larvae passed through six distinct instar and larval duration was 540 hours. Larvae make thick loose silken cocoon. The pre-pupae and pupae stage were completed in 304-362 hours with about 36.3 percent mortality. The adult period was of short duration. The sex ratio was 5 males to 6 females. One generation was completed in 6-7 weeks.

Under laboratory conditions, Ali *et. al.,* (1988) studied the biology of *S. oblique*. He observed that fecundity varied from 400-1000 eggs per female and there were nine generations from April to December.

Chatterjee and Chaudhary, (1989) studied the effect of different host plants on the development of *D. casignetum.* It was observed that total food consumption was highest in case of castor and lowest on jute. Development was faster on castor, which was most efficiently digested.

Gamundi *et. al.,* (1989) observed that when *S. virginica* fed on sunflower under laboratory condition, its mean larval duration was 19.9 days where as it was 27.7 days under field condition. Six instars were observed in both the conditions. Larvae of *S. obliqua* were collected in the field and reared in the laboratory. The first laboratory bred generation fed with various food and the effect on their development was investigated by Tiwari *et. al.,*(1989).

The larvae are large, tuberculate and densely covered with tufts of hairs and feed on the leaves of a variety o f plants. They are often extremely destructive. They are usually beautiful moths and can be easily recognized by the presence of a tymbal organ on the meta-episternum and a pre-spiracularcounter tympanal hood (Mani, 1990).

Singh and Singh, (1993) studied that comparative development and survival of caterpillar *(S. obliqua* Walker) at different temperature and varieties of sunflower. At 40°C there was no survival of larvae. Larval period, larval survival, pre-pupal and pupal period, pupal survival, pupal weight, fecundity, hatchability and incubation period decreased with increase in temperature from 25°C to 35°C. Adult longevity was maximum at 30°C.

The biology of *S. obliqua* on sunflower was studied by Singh and Singh, (1995). They observed six larval instars and the full grown larva was 42.17 mm in length. The larval stage was completed in 17.22 days during August-September and 50.43 days during November-January. Larval survival ranged from 45 to 95 percent during different months. The pupal period lasted 10.25 days in May and 67.88 days during January-March. There were six overlapping generations in a year. The average generation period varied from 37.50 days during April-June to 128 days during November-April.

Bhattacharya *et. al.*, (1995) studied the economic importance, biology and host range of *S. obliqua.* They observed that *S. obliqua* is one of the most serious polyphaghous insect pest causing damage to a variety of field and horticultural crops in India.

The average incubation larval, prepupal and pupal periods were 5.60, 24.72, 1.76 and 11.46 days, respectively and total life cycle was completed in 53.06 days on groundnut in case of *S. obliqua* as reported by Nath and Singh, (1996).

Another taxomomic attribute to recognize these moths is their hind wing venation, as the vein Sc + R always anastomoses with cell near or beyond its middle part and separate from vein Rs. The vein Sc basically tends to be swollen (Singh & Singh, 2002).

But, individuals of *S. obliqua* can be identified by the following characters: Full grown caterpillars measure about 45 mm long and have three black coloured bands with tufts of black hair and seven orange coloured broad transverse bands with tufts of yellow hairs. The adult moths are pale buff coloured medium sized with black spots on the wing. Wing expanse ranges from 35 to 55 mm.

2.1.2 Distribution of *Spilosoma obliqua*

S. obliqua has been reported to occur only in certain parts of South East Asia and it does not enjoy worldwide distribution. Besides India, it is known to occur in Bangladesh, Myanmar, Pakistan, Philippines and Sri Lanka (Anonymous, 1990; Singh & Sehgal, 1992). However, in the Indian context, this pest is practically reported from all over the country causing damage to a large number of cultivated as well as non-cultivated plant species (Fletcher, 1922; Mathur, 1962; Dutt, 1964; Gargav & Katiyar, 1971).

As this species being primarily polyphagous, its distribution and its density may differ from place to place, which may be in tune with climatic conditions of the place as well as the availability of natural enemies and pathogens in a given locality.

2.1.3 Host preference of *Spilosoma obliqua*

Pandey *et. al.*, (1968) reared the larvae of *Diacrisia obliqua* (Wlk.) on 12 natural food plants and recorded the effect of the diet on the larval and pupal development. On the basis of percentage of surviving larvae, larval weight gains, pupal weight, percentage of emergence of adults and the size and fecundity of the moths, *Sesamum indicum* was the most favorable food and *Crotalaria juncea* was the least, reducing the growth rate arid resulting in longer larval and pupal stages than any of the other plants. On the basis of the growth index, eight of the remaining plants could be arranged in order to decreasing suitability: Jute, cowpea, castor, cotton, groundnut and maize.

Chand, (1975) observed the feeding preferences of *D. obliqua* (Wlk.) on 20 species of economic plants, mostly table vegetables that are grown between August - November. The larvae were found to attack 14 food plants from the families of Leguminosae, Solanaceae, Cruciferae and Cucurbitaceae, especially preferring beans and radish.

Deshmukh *et. al.*, (1979) carried out experiments on *Spilosoma obliqua* (Wlk.) fed on different host plants at about 27°C, 85% RH. larvae did not complete development on egg-plants, probably because of physiochemical properties of the plants. Jute, Cotton, Bean, Maize and Soybean were more suitable as food plants as indicated by the higher survival rates of larvae.

God and Kumar, (1983) as part of their investigations on the development of *S. obliqua* (Wlk.) observed that food consumption during the larval development positively affected pupal weight.

Singh and Bhattacharya, (1994) made attempts to improve the quality of semi-synthetic diets when the flours of two distinct commodities, soybean and pea, were used in different ratios *(*25:75, 50:50 and 75:25*).* Based on various developmental parameters, the diets prepared *with* flour of soybean + pea *(*50:50*)* proved their suitability in rearing *Spilosoma obliqua* (Wlk.) over the rest of the diets.

Taleb, (1995) in his experiment, used the leaves of four host plants jute *(Corchorus capsularis),* Soybean *(Glycine max),* bean *(Dolichos lablab)* and cabbage *(Brassica oleracea* Var. Capitata) as food for *Spilosoma obliqua* in the laboratory. The consumption of cabbage leaves by the larvae and the nutrient contents such as crude protein and fat in soybean leaves were greater than for other host plants. However, the utilization of food in terms of quantity, nutrient uptake and growth indices of *S. obliqua* *w*as higher on jute and bean than on the other two host plants. Jute leaves, being Superior in quality significantly influenced the growth and development of *S. obliqua* followed by bean leaves. Soybean leaves showed the lowest performance.

2.1.4 Effect of temperature on developmental duration

Temperature also plays an important role in the development and survival of *S. obliqua.* For example, when the larvae were fed with sunflower leaves, the duration of larval stage marginally decreased with the increase of temperature (Singh & Singh, 1993). As for instance, the larval stage was completed in 22.75 ± 0.22, 22.4 ± 0.40 and 20.1 ± 0.49 days at 25, 30 and 35°C respectively. Similar effect was also observed with durations of pre-pupa and pupa i.e., less duration with increase of temperature. Variation in adult longevity was also noticed with varied temperature i.e., adult longevity was maximum (4.6 ± 0.29 days) at 30°C and minimum (2.75 ± 0.41 days) at 35°C. Further, fecundity, hatchability and incubation period also decreased with moderately increased temperature.

2.2 Control strategies

The availability of abundant food plant as well as conducive climatic condition in a given agro-ecosystem always promotes the insects to maintain high population level (Ananthakrishnan, 1992).

Therefore, attempts should be made to check the growth of pest density within the economic threshold level (Atwal & Dhaliwal, 1997). Although, a number of methods such as biological, chemical, cultural, microbial, hormonal, pheromonal and physical control methods are available to combat pest density, still, farmers depend upon chemical control to a greater extent even today, because it gives quick relief from insect damage by its spectacular knock down effect and easy availability in the open market (David, 2001). But intensive agriculture with indiscriminate use of pesticides and fertilizers leads to the problems like health hazards, environmental pollution and adverse effect on non-target organisms and unsuitable farming system. Total reliance on insecticides have resulted in grave consequences to crop production and protection.

However, due to the awareness programmes on pesticide pollution and environmental degradation, farmers try to adopt other safer methods and use chemicals as a need based option (Muraleedharan & Varatharajan, 1988).

Polan *et. al.*, (2009) reported that eight different insecticides were evaluated in the potted plants for the fixation of doses in the field trial, all the insecticides giving more 90% mortality after 72 hours spray and were found very much effective in controlling jute hairy caterpillar.

Recent report on the appraisal of crop loss indicates that the crop loss due to insect pests and disease in India is to the tune of Rs. 50,000 crore per annum (Jayaraj, 2002).

Realizing the importance of pest control, almost every year the government is organizing the national symposium on pest control strategies. It is relevant to state here that one such symposium has been recently conducted by the project directorate of biological control under the theme on **"**Biocontrol methods of Lepidopteran pest**"** (Tandon *et. al., 2002).*

Nath *et. al.,* (1991) reported that curative application was significantly superior over the preventive application of insecticides. Preventive plus curative schedule of insecticide application together appear to be better than individual performance of preventive or curative schedule especially under field condition. Generally it is difficult to control the older instars of lepidopteran larvae probably because of the presence of long hairs all over the body and it is also true in the case of *Spodoptera litura* (Fabricius) (Prasad & Premchand, 1981).

Tysowsky & Gallo, (1977); Rawat *et. al.,* (1981); Ho & Goh, (1984); Singh & Sarup, (1985); Vekaria & Vyas, (1985); Nagia *et. al., (*1989) and Patel *et. al., (*1989) have attempted to control insect pests even before eggs hatching into larvae i.e., using ovicides. The effects of ovicidal insecticides against different species of insects have been studied by Studies of Jena *et. al.,* (1985); Ghattas *et. al., (1987)* have highlighted the field trial on ovicides with special reference to certain species of plant hopper and cutworm. Goel & Sanjaykumar, (1991) studied the ovicides action of synthetic pyrethroids such as cypermethrin, deltamethrin, fenpropathrin, fenvalerate and fluvalinate against the eggs of *S. obliqua* and found them less effective. But it was effective against newly hatched larvae of *S. obliqua.*

The chitin inhibitor, Diflubenzuron was initially considered as stomach poison (Van Daalen *et. al.,* 1972) but later proved to possess ovicidal effect as it influenced developing larvae within the eggs. Diflubenzuron treated eggs have shown significant reduction in the emergence of adult besides, ovicidal activity which was found maximum when the eggs were 1 day old but least effective on 4th or 5th day old (Gupta *et. al.,* 1994). Contact ovicidal activity of diflubenzuron has also been demonstrated by Ascher & Nemmy, 1974 and Grosscurt, 1976.

Diflubenzuron is widely used against larvae especially under field condition. The young caterpillars of *S. obliqua* can be killed by dusting with malathion 5% @ 25 kg/ha. However, the full grown larvae may not respond to low dose of pesticide rather high concentrations are needed to check them effectively. Quinalphos 25 EC can also be used for the control of this pest (Atwal & Dhaliwal, 1997). Sidhu & Dhawan, (1980) reported that quinalphos and endosulfan were good in controlling the larvae of jute hairy caterpillar.

The grown up larvae of *S. obliqua* were also found susceptible to endosulfan, quinalphos, moncrotophos, phosalone and dichlorvos (Sagar & Ramzan, 1983). Mandal & Senapati, (1989) demonstrated that 0.05% concentration of endosulfan caused cent percent mortality within 1 day and acted as contact and stomach poison. Besides, they have also discussed the role of acetic acid in the field control of this larval pest. Banerjee & Datta, (1986) also reported that ascorbic acid and acetic acid have the antifeedant and insecticidal properties against *S. obliqua.* Although these two acids exhibited marked effect on the larvae of *S. obliqua*, acetic acid was found to manifest phytotoxic symptoms like scorching of the leaf, fruit and young stem. Therefore, the utility of both the acids has limitation in pest control especially under the field conditions.

Nath & Singh, (1996) also conducted an experiment on the efficacy of certain organophosphorus compounds and synthetic pyrethroids and found quite effective, especially with phosphamidon, endosulfan, malathion and dimlin etc. against the larvae of *S. obliqua.* It has also been reported that synthetic pyrethroids were proved to be the most potent insecticide against number of crop pests including *S. obliqua* (Rai *et. al*., 1980; Singh *et. al.,* 1987; Dhoble *et. al.,* 1996). Effect of quinalphos and endosulfan against this pest was also studied by Sidhu & Dhawan, (1980). As reported by Singh

(1991), among the emulsifiable concentrate insecticides, cypermethrin and decamethrin were found most effective, as there was 90% larval mortality after 24 hours ot application. In dust formulation quinalphos was most effective with 90% mortality of the larvae after 24 hours of treatment. Thus, one can find that the larvae of *S. obliqua* have been subjected to a number of chemical pesticides both in the laboratory and field conditions on a variety of crops at different agro-ecosystems. Even though, pesticide resistance character of *S. obliqua* has so far not been reported, but the time has come to change our strategy towards other means of control because of many disadvantages due to chemical insecticides. In this context, biocontrol plays a predominant role and the following text primarily pertains to different biocontrol agents operating under natural ecosystem.

2.2.1 Chemical control of *Spilosoma obliqua (*Walker) under laboratory condition

Tripathi, (1966) used sprays against *D. obliqua* Wlk and reported that endosulfan and parathion 1.16 and 1.15 times as toxic as endrin, while lindane proved to be less toxic than endrin being 0.69 times as toxic as endrin.

Bakhetia and Sidhu, (1971) tested thirteen insecticides in the field for the control of 4 and 5th instar larvae of *S. obliqua* Walker infesting tosha crop. Chlorfenvinphos, endosulfan, endrin and parathion as 0.05% high volume sprays (@800 L/ha) were very effective for its control. Prophylactic sprays against the migrating caterpillar did not prove fully effective. It was found that 64 to 92 percent larvae migrating out of the treated are and survived. It is therefore, summarized that control operation should be conducted over a large area to achieve on effective control of the pest.

Gargav and Bichoo, (1971) experimented under laboratory condition, to test the efficacy of different insecticides against *D. obliqua.* Third instar caterpillars were selected for the trial. The knock down action of Dursban, Boyrusil and folithion was very rapid on the caterpillars of *S. obliqua* Walker as within 24 hours, 100 percent mortality was recorded. Thiodan was very close and gave 100 percent mortality after 36 hours. The action of Nuvacron was slow and steady as all the caterpillars were killed within 72 hours after the treatment. Lebaycid and Ambithion were comparatively less toxic as they gave 66.6 and 56.6 percent mortality even after 72 hours.

Gargav and Katiyar, (1971) tested some insecticides against *D. obliqua.* Carbaryl and diazinon gave the highest mortality. Endosulfan was initially slow but within 48 hours gave 100 percent kill and was at par with diazinon and carbaryl. Malathion, Phosphomidan and dichlorvas gave above 60 percent mortality after 72 hours. All the insecticides gave the satisfactory control of the caterpillars.

Lakshman and Verma, (1980) tested four insecticides viz. malathion, monocrotophos phosphomidan and dimethoate against *D. obligua* on different host plants. On Bharongi (*Clerodendron siphohanthus).*Larvae were most susceptible to all the four insecticides in comparison to other hosts. Relative toxicity ratio within the host plants was minimum with monocrotophos (0.36), followed by phosphomidan (1.72), malathion (1.78) and dimethoate (2.14).

Sidhu and Dhawan, (1980) tested four new insecticides i.e. quinalphos, monocrotophos, phenthoate and phosalone and they were compared with endosulfan, fenitrothion were less effective. Mortality of mature larvae varied from 60-90 percent with higher dosage of 0.9 kg ai/ha of monocrotophos, quinalphos and endosulfan. Fenitrothion and carbaryl gave the moderate control of young and mature larvae. Monocrotophos, quinalphos and endosulfan @ 0.5 kg ai/ha were most effective against newly hatched larvae of *D. obliqua.*

Devendra Prasad and Premchand, (1981) conducted an experiment for controlling Bihar hairy caterpillar in advanced stage' of development in instar) both under laboratory as well as field condition. On the basis of lowest concentration giving at least 50 percent kill, were selected for application in the field. Sumithion (0.02%), folithion (0.05%) and Nuvacron (0.75%) gave best results after 24 hours in the laboratory. Brestan and Neem products showed best antifeeding properties against caterpillars in the laboratory. Monocrotophos (0.05%) gave maximum reduction in larval population in both, after 24 hours as well as 72 hours under field conditions. Nuvacron (0.025%), folithion (0.02%) and Sumithion (0.016%) remained at par.

Mrig and Singh, (1981) observed that out of 18 insecticides tested only three insecticides namely quinalphos (0.075 percent), endosulfan (0.15 percent) and dichlorvas (0.025 percent) caused very high mortality of the 5th and 7th instars caterpillars all the intervals in both the experiments. Hence any one of these considering the availability, price, toxicity etc. may be used to control these pests.

Premsagar and Ramzon, (1983) reported that quinalphos found to be the best against *D. obliqua* under laboratory conditions, followed by endosulfan, dichlorvas and formothion as they proved to be less effective.

Sinha *et. al.,* (1984) tested thirteen insecticides against the Bihar hairy caterpillar *(D. oblique).* Separately under three different situation Endosulfan (0.07%), Chlorfenvinphos (0.05%), dichlorvas (0.05%), quinalphos (0.05%), fenitrothion (0.05%) were found to be equally effective against the larvae of younger group feeding upon tested food, only few of these insecticides, namely chlorfenvinphos (0.05%), endosulfan (0.05%), fenthion (0.05%) and quinalphos (0.05%) were comparatively more effective. Against the grown up larvae too endosulfan (0.07%) followed by chlorpyriphos (0.05%), dichlorvas (0.05%), fenitrothion (0.05%) and quinalphos (0.05%) gave relatively better performance. However, when treated larvae feeding upon untreated food, only quinalphos (0.05%) could be able to give better control of grown up caterpillar.

Katiyar and Mukharjee, (1985) studied three group of organophosphorous viz.

phosphates, phosphorothionates and phosphorodithionates and compared them with a carbamate when applied to fourth instars caterpillar of *D. obliqua* Wlk. The order of toxicity among these categories of organophosphorous was phosphates > phosphorothionates > phosphorodithionates of the seven insecticides, monocrotophos and carbaryl demonstrated high toxicity for these caterpillar. The LC5Q / LC_{50}values were 0.019/ 0.090, 0.029/ 0.117, 0.045/ 0.335, 0.053/0.208, 0.061/ Q-.178, 0.076/ 0.162 and 0.101/ 0.381 percent for monocrotophos, carbaryl, Phosphomidan, fenitrothion, malathion, dimethoate and fenthion, respectively.

Yaciav *et. al.,*(1985) studied sixteen insecticides and count the mortality of both young and advanced stage larvae. It was concluded that methomyl proved most effective followed by quinalphos at all three levels of dosages. Endosulfan 35 EC at 0.05 percent and 0.10 percent and methyl parathion at 0.10 percent also proved quite effective and provided good mortality but were inferior to methomyl and quinalphos. The other insecticides did not show effective toxicity.

Chhabra and Kooner, (1987) concluded that the first instar caterpillar of *D. obliqua* may be successfully controlled by the dust formulation of fenval and BHC @ 15 kg and 25 kg/ha, respectively. Fenval dust (@ 15 kg/ha) gave effective control of second instar caterpillar. Fenval and thiodon spray formulation were toxic to the third instars caterpillar, whereas for full grown caterpillar fenval was more toxic than B.H.C.

Field trials were carried out in Uttar Pradesh, in 1978-79 by Gupta and Singh, (1988). It was reported that granular phorate, mephosfolan, disulfotan, carbafuran and aldicarb applied at 2 kg ai/ha sowing reduce the abundance of larvae of *Spodoptera. sp, D. obliqua* and *P. orichaltia* on green gram. Grain yield was also greater than in untreated varieties.

Six synthetic pyrethroids were compared with quinalphos against the arctiid *S. obliqua* on sesamum by Goel and Kumar, (1991). According to them deltamethrin was the mosteffective followed by cypermethrin, both were effective for15 days from spraying.

Khattak *et. al.,* (1991) tested with number of insecticides against *D. oblique* under laboratory condition. Monocrotophos and dichlorvas caused 100 percent mortality after 24 hours. Whereas, acephate, cyflythin, chlorfenvinphos and phenthoate caused 95.8, 87.5, 33.33 and 27.7 percent mortality respectively. As contact poison monocrotophos gave 87.5 percent mortality after 24 hours. Whereas, dichlorvas, cypermethrin, acephate, chlorfenvinphos and phenthoate gave 75.50, 42.5 percent mortality respectively. They recommended monocrotophos for the control of the pest.

In a field study conducted in New Delhi, India by Kundu, (1991) during the kharif season of 1990, Monocrotophos (0.04%) and malathion (0.05%) were effective than endosulfan (0.07%) or padan (cartap) (0.05%) in controlling infestation of *S. obliqua (Spilarctia obliqua)* on soybean. However, the highest concentrates of endosulfan (0.105%) gave almost 100% control. Cartap (0.05 and 0.1%) was less effective against last instar larvae than equivalent concentrate of monocrotophos, malathion or endosulfan.

Efficacy of nine insecticides against $4^{th}$and 5^{th}instars larvae of *S. obliqua* were tested by Nagia *et.al.,* (1991). The larvae were reared on castor leaves. Good results were achieved with cypermethrin and fenvalrate at 0.016% ai. Whereas, parathion, methyl and endosulfan at 0.08% ai, monocrotophos acephate, triazophos and diazinon proved less toxic to the pest.

Singh, (1991) tested some insecticides against the fourth instar larvae of the Bihar hairy caterpillar. Cypermethrin and decamethrin were most effective and gave 90 and 93.33 percent larval mortality 24 hours after treatment respectively. However, 72 hours after treatment cypermethrin, fenvalrate and decamethrin all synthetic pyrethroids were most effective and gave 93.33 to 100 percent larval mortality. After 24 hours of treatment cypermethrin, ripcord, fenvalrate and decamethrin all synthetic pyrethroids inflicted

93.33 to 100 percent mortality and were significantly more toxic than the traditional insecticides.

Senapathi and Surkali, (1994) evaluated with some insecticides (monocrotophos, endosulfan, quinalphos and chlorpyriphos) against *D. obliqua* on jute crop and reported that monocrotophos was the best among all as it resulted in highest yield of jute crop.

Ahuja and Bakhetia, (1995) reported that in India, sesame is attacked by a large number of insect pest of which the pyralid *Antigastra catalaunalis* is the most serious causing upto 90% yield loss. Other pest of importance are the cecidomyiid Asphandylia seasamae, the cicadellid *Orosius albicinctus* and the arctiid *S. obliqua.* This brief review discuses the biology, seasonal incidence, yield loss varietal resistance, natural enemy complex and management Practices for different insect pests.

Avinash *et. al.*,(1996) conducted an experiment with seven insecticides namely phorate (10g) and carbafuran (3g) each @ 1 kg ai/ha as a soil treatment once before sowing; and endosulfan 0.07 percent foliar spray and dusting of each of quinalphos (1-5% dust), Fenvalrate (4% dust), methyl parathion (2% dust) and malathion (5% dust) @ 20 kg/ha were used twice during the crop season for the control of *S. obliqua* in *vigno mungo* in Bihar. The treatment differences were statistically significant. Spraying with 0.07 percent endosulfan or dusting with 2 percent methyl parathion dusts were significantly superior in respect of minimizing the damage.

Biswas *et. al.*,(1996) carried out studies with castor *(R. communis)* in India to evaluate the relative toxicity of six insecticides- (endosulfan, B.H.C., malathion, quinalphos, fenvalrate and cypermethrin) alone and in combination with sub-lethal concentration of Dipel (*Bacillus thuringiensis* sub sp. Kurstaki) against 7 days old larvae of *S. oblique* (Wlk). The results showed that (compared to malathion) cypermethrin and fenvalrate were 11.7 and 10.55 times more toxic, respectively, followed by quinalphos (2.27 times).

Dipel was compatible with all insecticides, but insecticides at lower concentrations became more toxic, when they 'were used in conjunction with Dipel. Dipel with quinalphos showed greatest toxicity (8.51 times.).

Kodapatti *et. al.,* (1996) did the field experiment in 1993 in Karnataka. He selected insecticidal formulation (Ec, dust and poison bait) and they were evaluated against 2nd and 4th instar larvae of *S. obliqua* on sunflower. Fenvalrate spray (0.01%) and dust (0.04%), endosulfan spray (0.07%) and dust (4.0%) were the most effective treatments against the larvae after 24, 48 hours days after the application. He found that mortality was higher in the 2nd instar than 4th instar.

Mukhopadhyay and Senapathi, (1996) observed that the sugarbeet *(Beta vulgoris)* is infested by *S. obliqua* in costal West Bengal. He found that the application of 0.75 kg malathiona a.i./ha, 16 weeks after sowing in December sown plants was effective in controlling these pest.

Rane *et. al.,* (1996) conducted field experiments with soybean cv. monetta in Nagpur, Maharashtra, India, and tested the efficacy of six different insecticides against *S. obliqua.* He found the greatest reduction in larval population and greatest yield with phosphomidan @ 0.03%.

It was reported (Anon. 2013) that Seven insecticides were evaluated against jute hairy caterpillar in the fields of Central station, Dhaka and JAES, Manikganj. Cure 40SL, Nice 45SC, Emazoate 5SG, Goldimida 20SL, Macgor 40EC, Procure 5SG and Thunder 70 WDG @ 1.85 L/ha, 250ml/ha, 1.5kg/ha, 750ml/ha, 1L/ha, 1.5kg/ha and 100gm/ha respectively were found effective against jute hairy caterpillar giving more than 82.80 percent reduction of infestation at 7 days after spray.

It was reported (Anon. 2015) that Seven insecticides were evaluated against jute hairy caterpillar in the fields of Central station, Dhaka and JAES, Manikganj. Laser 10WDG, Achamka Plus 6WDG, Chatfat 10WDG, Over 40%WDG, Comon 6%WDG, Fusion 20SL, Amber 40WDG, Rescue 6WDG and Aktic 24SC @ 750gm/ha, 250gm/ha, 750gm/ha, 750gm/ha, 250gm/ha, 500ml/ha, 75gm/ha, 250gm/ha and 750ml/ha respectively were found effective against jute hairy caterpillar giving more than 88.20 percent reduction of infestation at 7 days after spray.

It was reported (Anon. 2016) that Thirty two new insecticides were evaluated against jute hairy caterpillar in the fields of Central station, Dhaka and JAES, Manikganj. Orozon 10G, Panchatara 5SG, Meron 5EC, Benz 60WDG, Emilon 20Sl, Hakdak 45WG, Achta 1%EC, Capture 75WDG, Capture 40%WDG, Lufa 55EC, Marzan 6.5SL, Abtin 1.8EC, Cought 40WDG, Forecho 60EC, Thiema 40WG, Kerazate 5WDG, Ble-king 70WG, Expert 70WDG, Hosamectin 5SG, Talent 5WDG, Fiprid 80WDG, G-Zot 40WG, G-Chamka 6WDG, Xenon Plus 50WG, Alite 6WDG, Aline 40WDG, Luret 50WDG, Benefit 5.7WDG, Pabama 60WG, Emazoate 10WDG, Complain 40%WDG, Haymanil 55WDG were tested along with Hayzinon 60EC (standard) respectively were found effective against jute hairy caterpillar giving more than 80 percent reduction of infestation at 7 days after spray.

CHAPTER III

MATERIALS AND METHODS

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MATERIALS AND METHODS

The experiments were carried out in laboratory, greenhouse and in the field during March to December, 2017. The details of different materials used and methodology followed during the experimental period are presented below.

3.1 Experimental site

The research work was carried out at laboratory and Greenhouse premises of BJRI, Dhaka and in the experimental field of Jute Agriculture Experimental Station (JAES), Manikganj and Central station, Dhaka.

3.2 Soil

The experimental area is belonging to the Agro-Ecological Zone (AEZ-7) "Active Brahmaputra and Jamuna Floodplain". The soil texture was sandy loam.

3.3 Climate

The experimental area was under the subtropical climate. Usually the rainfall was heavy during Kharif season and scantly in Rabi season. The atmospheric temperatures increased as the growing period proceeded towards Kharif season. The weather conditions of crop growth period such as monthly mean rainfall (mm), mean temperature (^{0}C), sunshine hours and humidity (%) were collected from weather center of JAES, Manikganj and presented.

3.4 Land preparation

The land was prepared at 'JOE' condition by deep ploughing and harrowing followed by laddering and leveled properly. The seeds were sown after final preparation of land.

3.5 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications following the methods described by Gomez and Gomez, (1984).

3.6 Plot size

The size of the individual plot was 3 m × 2.1 m. The space between plot to plot and line to line was 0.75 m and 0.3 m, respectively.

3.7 Fertilizer Application

The following fertilizers (As prescribed fertilizer recommendation of Soil science department of BJRI) were used.

Name of the fertilizers	Rate (kg/ha)
Urea	200
TSP	50
MP	60
Gypsum	95
$ZnSO_4$	11

The total amount of TSP, MP, Gypsum, Zinc sulphate and the half of urea were applied at the time of final land preparation. The remaining half of the urea was applied after 45 days of seed sowing.

3.8 Planting materials

The variety O-9897 of *Corchorus olitorius* L. was used. The seeds were collected from the Breeder Seed Department of BJRI. Before sowing, seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90%.

3.9 Pot preparation

Earthen pots (10´´ diameter) were brought from the market and filled with dairy soil and sand.

3.10 Inter cultural operation

Weeding, mulching and irrigation were done as and when necessary but no plant protection measures were taken.

3.11 The test insect

Test insect was jute hairy caterpillar, *Spilosoma obliqua* (Walker), (Order: Lepidoptera, Family: Arctiidae).

Experiment 1: Study on biology of jute hairy caterpillar under laboratory condition.

Biology: The study was conducted in the laboratory of Entomology division, Bangladesh Jute Research Institute, Dhaka during jute growing season (March to August, 2017). Field collected larvae of jute hairy caterpillar *Spilosoma obliqua* were reared on potted jute plants in the laboratory. Potted plants were covered with mosquito net. After emergence, the adults were allowed to mate for egg laying. After hatching the larvae were reared in the plastic pot with green leaves in support with aeration. Data on different growth stages of *S. oblique* were recorded along with room temperature and relative humidity.

Plate 1: Insect rearing under laboratory condition

Plate 2: Insect rearing under net house condition

Plate 3: Insect for mating purpose to multiply generation under laboratory condition

Experiment 2. Field trial of some chemical insecticides against jute hairy caterpillar.

3.12 Control methods

The study was conducted at the laboratory of Entomology Department. The experiment was conducted at three different locations. Pot experiment was conducted at net house of Bangladesh Jute Research Institute (BJRI) and field experiment were conducted at Jute Agriculture Experimental Station (JAES), Manikganj and Central station, Dhaka during the jute growing season (April - August) 2017. Seven insecticides of different common and trade names and a control were used in this experiment which were

1. Emacto 5WDG (Emamectin Benzoate)
2. Fusion 20SL (Imidacloprid)
3. Rescue 6WDG (Abamectin 2% + Emamectin Benzoate 4% WDG)
4. Hayron 5EC (Lufenuron)
5. Base 45SP (Spinosad)
6. Perfect 30WDG (Lufenuron 10% + Thiamethoxam 20%)
7. Mekalux 25EC (Quinalphos)
8. Control

3.13 Pot experiment

Jute variety O-9897 was grown in earthen pot at greenhouse premises of Central station, BJRI, Dhaka. Three pots were used for each treatment where five plants were allowed in each pot. Plants of each pot were covered with mosquito net so that insect cannot move from one pot to another. Twenty caterpillar (3rd instar) larvae were released on the 45 days old plants of each pot covered with mosquito net. Next day three doses of each insecticide were sprayed on the potted plants. Number of live hairy caterpillar was counted after 3 and 5 days of spray.

Percent mortality was calculated following a formula given below.

$$\text{\%Mortality} = \frac{\text{No. of live insects before spray - No. of live insects after spray}}{\text{No. of live insects before spray}} \times 100$$

Data were analyzed by Statistix-10 software and means were separated by Duncan's Multiple Range Test (DMRT).

3.14 Field experiment

Treatment	Common name	Trade name	Dose/ha
T1	Emamectin Benzoate	Emacto 5WDG	1.5kg
T2	Imidacloprid	Fusion 20SL	500ml
T3	Abamectin 2% +Emamectin Benzoate 4% WDG	Rescue 6WDG	250 gm
T4	Lufenuron	Hayron 5EC	500 ml
T5	Spinosad	Base 45SP	250ml
T6	Lufenuron 10%+ Thiamethoxam 20%	Perfect 30WDG	100gm
T7	Quinalphos	Mekalux 25EC	1.5L
T8	Untreated control		

Field experiment was conducted in two different locations *viz.* one in JAES, Manikganj and another in central station, Dhaka. The jute variety O-9897 was grown in unit plot size of 2 x 2.1 m^2 with four replication following Randomized Complete Block Design (RCBD). Seven new insecticides Emacto 5WDG (Emamectin Benzoate), Fusion 20SL (Imidacloprid), Rescue 6WDG (Abamectin 2% + Emamectin Benzoate 4% WDG), Hayron 5EC (Lufenuron), Base45SP (Spinosad), Perfect 30WDG (Lufenuron 10% + Thiamethoxam 20%) and Mekalux 25EC (Quinalphos) @ 1.5kg/ha, 500ml/ha, 250 gm/ha, 500 ml/ha, 250ml/ha, 100gm/ha, 1.5L/ha respectively were sprayed after 60 days of sowing when sufficient infestation was found in the plot naturally. No insecticide was sprayed in control plots. Population of caterpillar in each plot was recorded before spray and at 3rd and 7th day after spray.

Percent reduction of infestation over control was calculated following a formula given below:

$$\textbf{\%Reduction over control} = \frac{\text{No. of insects in control plot - No. of insects in treated plot}}{\text{No. of insects in control Plot}} \times 100$$

Data were analyzed by Statistix-10 software and means were separated by Duncan's Multiple Range Test (DMRT).

Plate 4: Jute hairy caterpillar infested plant (net house)

Plate 5: Jute hairy caterpillar infested plant in field

Plate 6: Partial view of the treatment plot, JAES, Manikganj

Plate 7: Partial view of the treatment plot, Central station, Dhaka

CHAPTER- IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and explanation of the results obtained from the experiment on biology and chemical control of Jute hairy caterpillar. The data have been presented and discussed and possible interpretations are made under the following headings:

4.1 Biology of Jute hairy caterpillar, *Spilosoma obliqua*

The study on biology of *S. obliqua* on Jute plant was carried out at Department of Entomology, BJRI, Dhaka during March to October, 2017. The research was carried out at the temperature of 23.60 to 33.7 °C with an average of 28.82 ± 0.07 °C and Relative humidity of 42 to 71 percent with an average of 65 ± 5.09 percent in laboratory condition. The growth parameters such as egg, larvae, pupae and adult developmental periods recorded was presented in Table 1.

4.1.1 Egg

4.1.1.1 Oviposition site of *Spilosoma obliqua*

The oviposition site was recorded by observing different parts of the jute plant on which eggs were laid. The results showed that the female moths laid the eggs in masses on lower surface of the jute leaves. Further, different spots of field were observed and found that many egg masses were laid by single female on single plant. Similar egg laying pattern of *S. obliqua* was observed by different research workers (Singh and Singh, 1990; Ganiger and Sannaveerappaxiavar, 2007).

Thus, present findings (plate 8) are in close conformity with the results of earlier research workers.

Plate 8: Ovipositional site of *Spilosoma obliqua*

4.1.1.2 Colour, shape and size of *Spilosoma obliqua* eggs

Colour, shape and size of the eggs laid by *S. obliqua,* were recorded by observing eggs under the stereoscopic binocular microscope. The observations (Plate 9) on these characters revealed that the eggs of *S. obliqua* were greenish when it was first deposited thereafter; it turned to creamish and became dark black prior to hatching. The eggs were laid in masses or clusters which look like seed of grape from upper side.

The eggs are round on upper surface and flattened at base. Further, the diameter of eggs was found to be 0.32 to 0.55 mm with an average of 0.45 ± 0.014 mm (Table 3).

Plate 9: Eggs of *Spilosoma obliqua*

4.1.1.3 Incubation period of *Spilosoma obliqua* eggs

The observations on incubation period of *S. obliqua* started immediately after the egg laying and continued up to hatching. The incubation period varied from 4 to 7 days with an average of 5.5 ± 0.29 days (Table 1). Results of the present investigation on incubation period of *S. obliqua* were in close agreement with the results of the earlier workers as they recorded the incubation period of eggs in the range of 3-12 days (Singh and Singh, 1995); 5.60 days (Nath and Singh, 1996) and 6.5 to 10.5 days (Debaraj and Singh, 2010).

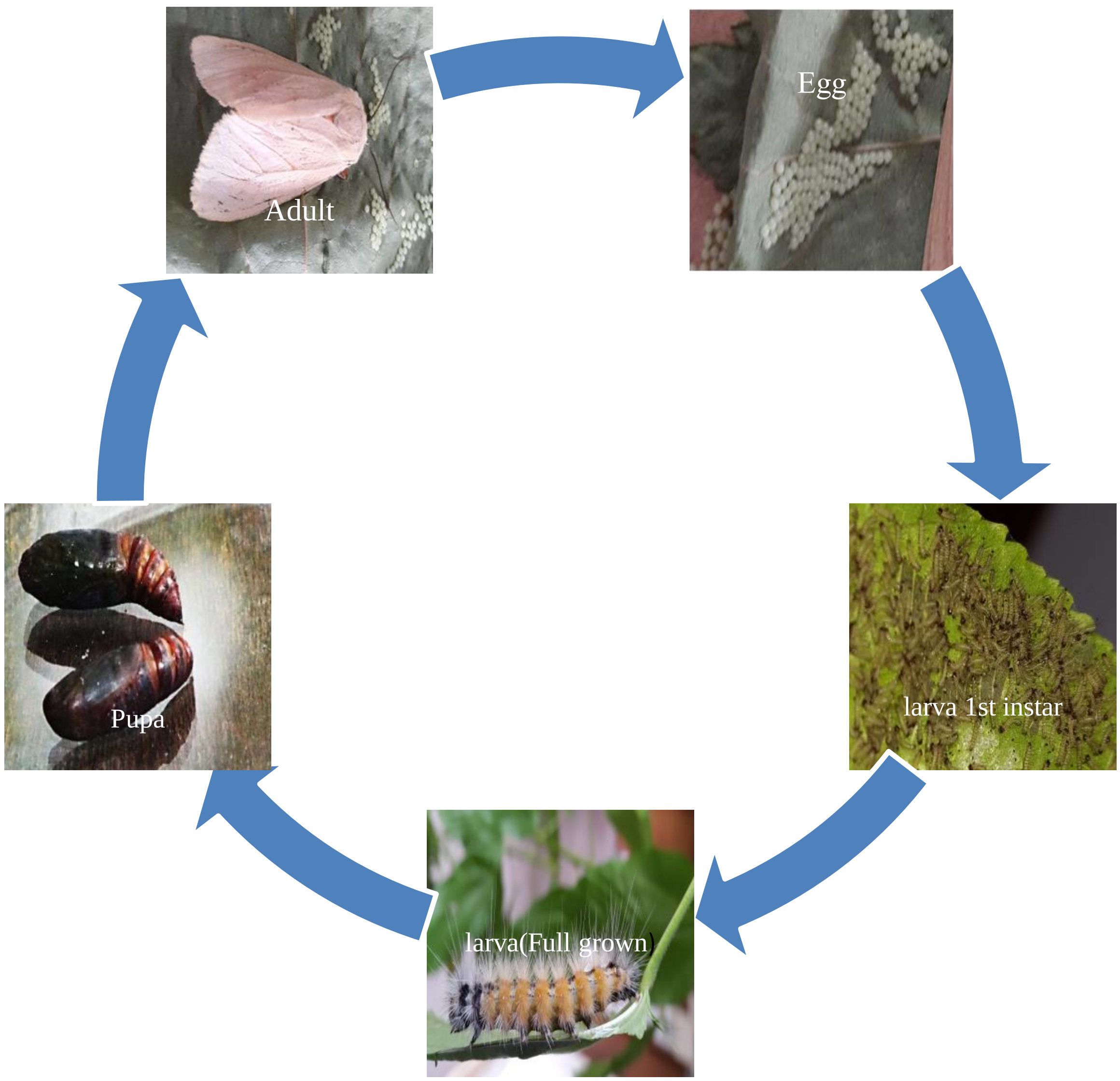

Figure 1. Life cycle of Jute Hairy Caterpillar

Table 1. The duration of egg and immature stages and egg-adult of *Spilosoma obliqua* under laboratory condition

Developmental stages	Days ± SE
Egg	5.5 ± 0.29
Larva	19.91 ± 0.47
Pupa	9.83 ± 0.42
Egg-adult(female) Egg-adult(male)	42.67 ± 0.69 38.67 ± 0.75
Room Temp(◦c)	28.82 ± 0.069
%RH	65 ± 5.099

4.1.2 Larva

4.1.2.1 Nature of damage and behavior of *Spilosoma obliqua* larvae

The observation on nature of damage due to Jute hairy caterpillar, *S. obliqua* were made visually in laboratory as well as in field conditions and it was found that the newly hatched larvae of *S. obliqua* fed gregariously on lower surface of leaves by scraping its surface which resulted in to papery leaves (Plate 10). Larvae of third, fourth and fifth instar fed the whole leaves except veins and veinlets. It was also found that the larvae stopped feeding for few hours before moulting.

Plate 10: Jute hairy caterpillar infested leaf

4.1.2.2 Larval instars

The observations were made on duration and morphometry (length, width) of different instars of *S. obliqua* with the help of stereoscopic binocular microscope. It was found that the larvae passed through sixth instars on jute plant leaves under the laboratory condition. The results on larval periods as well as morphometries are presented in the Table 2.

4.1.2.3 First instar

The newly hatched larva was creamy white with shining brown head and having brown spots over entire body from which white hair arises which later turn black. The integument was transparent, abdominal segments were distinct with three pairs of prologs. Larvae turned pale yellow colour within a few hours after hatching (Plate 11). The duration of first instar was found to be 2 to 4 days with an average of 3 ± 0.25 days.

Further, it was also found that the length and breadth of first instar larvae 4 to 6.2 mm with an average of 5.24 ± 0.21 mm and 0.8 to 1.30 mm with an average of 1.04 ± 0.065 mm, respectively (Table 2).

Plate 11: 1st instar larva

Table 2. Different larval instars, their duration and size of jute hairy caterpillar in jute season

Instars	Duration(in days)	Length(mm) ± SE	Breadth(mm) ± SE
1st	3 ± 0.25	5.24 ± 0.21	1.04 ± 0.065
2nd	5.5 ± 0.28	10 ± 0.43	2.57 ± 0.080
3rd	8.41 ± 0.45	15.23 ± 0.42	3.99 ± 0.125
4th	11.08 ± 0.37	24.92 ± 0.33	5.58 ± 0.110
5th	16.66 ± 0.37	36.48 ± 0.16	6.64 ± 0.132
6th	20.16 ± 0.32	43.57 ± 0.11	7.73 ± 0.066

4.1.2.4 Second instar

The larva in second instar slightly increased in size having light yellow colour body with brown markings on thoracic and last abdominal segment, more hairs on the body compared to first instar and thoracic legs were black with brown abdominal legs (Plate 12). The duration of second instar was varied from 4 to 7 days with an average of 5.5 ± 0.28 days. Further, it was found that the lengths and breadths of second instar larvae were from 8 to 11.30 mm with an average of 10 ± 0.43 mm and 2.2 to 3 mm with an average of 2.57 ± 0.08 mm respectively (Table 2).

Plate 12: 2nd instar larvae

4.1.2.5 Third instar

Third instar larvae were similar to second instar but the colouration of head and body segments were little darker compared to the second instar (Plate 13). The third instar larvae were more active than the first and second instar larvae. The duration of third instar were found to be from 7 to 10 days with an average of 8.41 ± 0.45 days. Further, it was also found that the lengths and breadths of third instar larvae were varied from 11.5 to 16 mm with an average of 15.23 ± 0.42 mm and 3.5 to 4.5 mm with an average of 3.99 ± 0.125mm respectively (Table 2).

Plate 13: 3rd instar larvae

4.1.2.6 Fourth instar

The larva in fourth instar were uniformly yellowish as the segments were brown and tuft of brownish white hairs arose from reddish brown verrucae and when the larvae approached late fourth instar stage, the head turned dark brownish black (Plate 14). The data (Table 2) on fourth instar larvae revealed that the duration of fourth instar larvae was from 9 to 13 days with an average of 11.08 ± 0.37 days. Further, it was also found that the lengths and breadths of fourth instar larvae were found from 22.50 to 26 mm with an average of 24.92 ± 0.33 mm and 5 to 6 mm with an average of 5.58 ± 0.11 mm respectively (Table 2).

Plate 14: 4th instar larvae

4.1.2.7 Fifth instar

The fifth instar larvae were dark yellow with reddish tinge in colour and the heads and thoracic shields were dark brown in colour while the legs were found to be reddish brown. Spiracles were inconspicuous and visible only under magnification as circular patches (Plate 15). The data (Table 2) on fifth instar larvae of *S. obliqua* revealed that the duration was varied from 15 to 19 days with an average of 16.66 ± 0.37days. Further, it was also found that the lengths and breadths of fifth instar larvae varied from 35.50 to 37 mm with an average of 36.48 ± 0.16mm and 6.50 to 7.20 mm with an average of 6.64 ± 0.132 mm, respectively (Table 2).

Plate 15: 5th instar larvae

4.1.2.8 Sixth instar

The fully grown sixth instar larva had dark black head with brownish legs and uniformly reddish brown body with brownish black verrucae on which there were whitish hairs (Plate 16). The data (Table 2) on sixth instar larvae revealed that the duration varied from 18 to 22 days with an average of 20.16 ± 0.32 days. Further, it was also found that the lengths and breadths of sixth instar larva were varied from 43 to 44 mm with an average of 43.57 ± 0.11mm and 7.5 to 8 mm with an average of 7.73 ± 0.066 mm respectively (Table 2).

Plate 16: 6th instar larvae (full grown)

4.1.2.9 Total larval duration

The total larval period (Table 1) of *S. obliqua* was ranged from 17 to 22 days with an average of 19.91 ± 0.47 days. Earlier workers also reported larval period of 17.22 days (Singh and Singh, 1995), 24.72 days (Nath and Singh, 1996) and 24 days (Debaraj and Singh, 2010), 18-20 days (Islam and Banu, 2013).

4.1.4 Pupae

4.1.4.1 Site of pupation, colour and shape

The observation on site of pupation, colour and shape were visually recorded in laboratory. It was revealed that the larvae of *S. obliqua* pupated in the moist soil kept in galvanized cage. The pupae were found in earthen cocoons composed of dry hairs and caste of skin. The newly formed pupae were soft and pale brown in colour. Later on, the pupa turned brownish in colour (Plate 17).

Plate 17: Site and pupa of jute hairy caterpillar

4.1.4.2 Pupal period

The duration of pupae varied from 8 to 12 days with an average of 9.83 ± 0.42 days, (Table 1). The present findings are in close conformity with the report of Singh and Singh, (1995) and Nath and Singh, (1996) in which they reported pupal period of 10.25 days and 11.46 days. Islam and Banu, (2013) reported pupal period of 9-10 days.

Table 3. Length and breath of different stages of jute hairy caterpillar

Developmental stages	Average length (mm) (mean ± SE)	Average breath(mm)
Egg (diameter)	0.45 ± 0.014	
Larvae(full grown)	43.56 ± 0.116	7.73 ± 0.066
Pupa	17.45 ± 0.034	5.45 ± 0.013
Adult male	15.19 ± 0.045	4.47 ± 0.014
Adult female	15.74 ± 0.035	5.07 ± 0.010

4.1.4.3 Morphometric of pupae

The observations on size of pupae were recorded with the help of binocular microscope in laboratory. The results revealed that the lengths of pupae were found in the range of 17.3 to 17.6 mm with an average of 17.45 ± 0.034 mm. In case of widths of the pupae, it was found in the range of 5.4 to 5.5 mm with an average of 5.54 ± 0.013 mm (Table 3).

4.1.5 Adult

4.1.5.1 Colour and appearance

The observations were made on colour and appearance of the *S. obliqua* adults. It was found that the moths were straw in colour with orange and brown streaks over the forewings and white streak along the anterior margin and reddish abdomen. The hind wings were found yellowish in colour with black markings (Plate 18).

Plate 18: Adult moth of Jute hairy caterpillar

4.1.5.2 Size

The observations were made on size of the *S. obliqua* adults and it was found that the lengths of male moths ranged from 15 to 15.40 mm with an average of 15.19 ± 0.045mm (Table 3) while the lengths of the female moths were ranged from 15.6 to 16 mm with an average of 15.74 ± 0.035mm.

4.1.5.3 Pre-oviposition, oviposition periods

Oviposition generally occurs at night. The observations were made on pre-oviposition, oviposition periods of *S. obliqua* in laboratory and found that the pre-oviposition period varied from 1 to 2 days with an average of 1.42 ± 0.15days (Table 4) while oviposition period ranged from 3 to 5 days with an average of 3.5 ± 0.29 days (Table 4). According to Singh and Singh, (1995) and Nath and Singh, (1996), pre-oviposition, oviposition periods were 2.14 to 2.40; 2.44 to 2.88 days, respectively. The present findings are in close conformity with the report of Singh and Singh, (1995) and Nath and Singh, (1996).

Table 4. Pre-Oviposition, oviposition and longevity of jute hairy caterpillar moth under laboratory condition

Parameters	Days ± SE
Pre-Oviposition	1.42 ± 0.15
Oviposition	3.5 ± 0.29
Female longevity	7.41 ± 0.34
Male longevity	3.42 ± 0.26
Room temp(◦c)	28.82 ± 0.069
%RH	65 ± 5.099

4.1.5.4 Longevity

The data on longevity of female moths were found in the range of 6 to 9 days with an average of 7.41 ± 0.34 days, while in case of male moths it was found to be of 2 to 5 days with an average of 3.42 ± 0.26 days (Table 4).

4.1.6 Total life span

The total life span was found to be of 37 to 40 days with an average of 38.67 ± 0.75 days in case of male, while it was ranged from 40 to 45 days with an average of 42.67 ± 0.69 days in case of female. The present findings are in close conformity with the report of

Singh and Singh, (1995), Nath and Singh, (1994) and Debaraj and Singh, (2010) as they reported that the total life span was found to be 37.50; 53.06 and 39.60 days respectively.

4.2 Efficacy of selected insecticides against jute hairy caterpillar in the field condition

To find out the effective insecticides for the management of *S. obliqua* infesting jute plant, seven insecticides were evaluated in the laboratory as well as field conditions during *kharif*, 2017. The data obtained from laboratory experiment are presented in table 5 and in table 6 and 7 for field experiment.

4.2.1 Laboratory trial

Different insecticides were evaluated for their efficacy against third, fourth and fifth instar larvae of *S. obliqua* in laboratory conditions. The mortality of *S. obliqua* larvae was recorded and corrected percent mortality was worked out. Thus, the data obtained on mortality of third to fifth instar larvae are presented in Table 5.

Efficacy of different doses of insecticides against Jute Hairy caterpillar at net house

At net house, three doses of all insecticides were applied. It was found from the (Table 5) that the higher doses were little more effective than the median doses. So, medium doses were selected and evaluated against Jute hairy caterpillar in the field of Central station, Dhaka and JAES, Manikganj. Detailed results are given in the table 5.

Polan *et. al.*, (2009) reported that eight different insecticides were evaluated in the potted plants for the fixation of doses in the field trial, all the insecticides giving more 90% mortality after 72 hours spray and were found very much effective in controlling jute hairy caterpillar.

The present results also indicate that all insecticides were quite effective against jute hairy caterpillar in the potted plants. However, the middle dose of these chemical were considered as the effective one for the control of around 90% population of the pest.

Table 5. Efficacy of different doses of insecticides against Jute Hairy caterpillar at net house

Treatments	Doses		Caterpillar per pot before spray	% mortality after spray	
	Dose/Liter	Dose/ha		3rd day	7th day
T1	4g 3g 2g	2kg 1.5kg 1kg	20 20 20	91.70 88.35 83.35	93.33 90 86.67
T2	1.5ml 1ml 0.5ml	750ml 500ml 250ml	20 20 20	93.75 90 88.35	97.50 91.70 86.70
T3	1g 0.5 0.25	500g 250g 125g	20 20 20	90 85 80	95 91.70 85
T4	1.5ml 1ml 0.5ml	750ml 500ml 250ml	20 20 20	90 83.50 80	95 90 85
T5	1ml 0.5ml 0.25ml	500ml 250ml 125ml	20 20 20	90 88.35 80	97.50 93.33 88.33
T6	0.3g 0.20g 0.15g	150g 100g 75g	20 20 20	88.35 83.35 78.35	93.33 90 88.35
T7	4ml 3ml 2ml	2L 1.5L 1L	20 20 20	90 85 83.50	95 91.70 88.35

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250 gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, and T_7= Mekalux 25EC @ 1.5L/ha.]

4.2.2 Field trial

4.2.2.1 Larval population

An experiment was conducted to evaluate different insecticides for their comparative efficacy against *S. obliqua* on jute plant in the field of JAES, Manikganj and BJRI, central station, Dhaka during *kharif*, 2017. The data obtained are presented in Table 6 and Table 7.

There was no significant difference in larval population among different treatments before spray. All the insecticidal treatments significantly reduced the larval population as compared to control during experimentation.

4.2.2.2 Effect of different insecticides in controlling jute hairy caterpillar under field condition at JAES, Manikganj during 2017

The experiment was conducted at JAES, Manikganj during 2017. The effect of different chemical insecticides on percent reduction over control of plant infestation by jute hairy caterpillar was determined in the field. Results of Table 6 reveals that in case of 3 days after treatment, the highest percent reduction of plant infestation (90.14%) was recorded Mekalux 25EC treated plot followed by Base 45SP (85.09%), Fusion 20SL (83.51%) which were statistically similar, the lowest percent reduction of plant infestation (79.62%) was recorded Emacto 5WDG treated plot followed by Rescue 30 WDG (80.98%), Perfect 30WDG (81.11%) and Hayron 5EC (82.93%) respectively.

In case of 7 days after treatment, the highest percent reduction of plant infestation (95.75%) was recorded Mekalux 25EC treated plot followed by Base 45SP (90.87%), Fusion 20SL (88.87%) respectively. Which were statistically similar. The lowest percent reduction of plant infestation (81.95%) was recorded Emacto 5WDG treated plot followed by Perfect 30WDG (84.23%), Rescue 30 WDG (85.76%) and Hayron 5EC (86.39%) respectively. All insecticides were found effective for controlling jute hairy caterpillar giving more than 80% reduction of plant infestation.

Polan *et. al.*, (2009) reported that eight different insecticides viz. Fenvet 20EC, Celcron 50EC, King Lamda 2.5Ec, Kalvin 85WP, Queenphos 25EC, Lavin 85WP, Emite 5WDG and Noknon 60EC were evaluated in the potted plants @ 500ml/ha, 550ml/ha, 1lit/ha, 1.5kg/ha, 1lit/ha, 500gm/ha, 1.5kg/ha and 1.7lit/ha respectively and found effective against jute hairy caterpillar giving 88.81, 92.50, 88.97, 88.77, 89.10, 88.23, 89.03, 90.70 and 88.78% reduction of infestation over control respectively at JAES, Manikganj.

It was reported (Anon. 2016) that Thirty two new insecticides were evaluated against jute hairy caterpillar in the fields of JAES, Manikganj. Orozon 10G, Panchatara 5SG, Meron 5EC, Benz 60WDG, Emilon 20Sl, Hakdak 45WG, Achta 1%EC, Capture 75WDG, Capture 40%WDG, Lufa 55EC, Marzan 6.5SL, Abtin 1.8EC, Cought 40WDG, Forecho 60EC, Thiema 40WG, Kerazate 5WDG, Ble-king 70WG, Expert 70WDG, Hosamectin 5SG, Talent 5WDG, Fiprid 80WDG, G-Zot 40WG, G-Chamka 6WDG, Xenon Plus 50WG, Alite 6WDG, Aline 40WDG, Luret 50WDG, Benefit 5.7WDG, Pabama 60WG, Emazoate 10WDG, Complain 40%WDG, Haymanil 55WDG were tested along with Hayzinon 60EC (standard) respectively were found effective against jute hairy caterpillar giving more than 80 percent reduction of infestation at 7 days after spray.

Table 6. Field efficacy of selected insecticides against jute hairy caterpillar in the field of JAES, Manikganj during 2017

Name of the insecticides	Dose/Ha	No of caterpillar before spray	% reduction of insecticides over control after spray at	
			3rd Day	7th Day
T1	1.5kg	38.5	79.62 b	81.95c
T2	500ml	31	83.51 ab	88.87 abc
T3	250g	37.25	80.98 b	85.76 bc
T4	500ml	36.25	82.93 b	86.39 bc
T5	250ml	30.5	85.09 ab	90.87 ab
T6	100g	28.25	81.11 b	84.23 bc
T7	1.5L	32.5	90.14 a	95.75 a
T8	0	37.5	---	---
CV%	----	11.38	6.63	6.34
$Lsd_{(0.05)}$	----	----	7.09	7.16

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250 gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

From the above findings it revealed that in case of 3rd day after spray Mekalux 25EC (T_7) performed as the best treatment in decreasing larval infestation (90.14%) during the management of jute hairy caterpillar followed by Base 45SP (T_5) (85.09%). In case of other treatments in decreasing larval infestation during the management of jute hairy caterpillar were 83.51%, 82.29%, 81.11%, 80.98% and 79.62% in Fusion 20SL (T_2), Hayron 5EC (T_4), Perfect 30WDG (T_6), Rescue 6WDG (T_3) and Emacto 5WDG (T1), respectively. As a result, the order of efficacy in terms of decreasing the percent larval infestation is $T_7 > T_5 > T_2 > T_4 > T_6 > T_3 > T_1$.

Again in terms of percent larval reduction over control respectively after 7th days of spray, highest larval reduction was observed in T_7 (95.75%) treatment followed by T_5 (90.87%) treated plots which was statistically similar with T_2 but there is significant difference among the treatments.

In terms of the lowest percent reduction of jute hairy caterpillar (81.95%) was recorded in T_1 treated plots during cropping season.

From the above findings it is revealed that in case of 7th day after spray Mekalux 25EC (T_7) performed as the best treatment in decreasing larval infestation (95.75%) during the management of jute hairy caterpillar followed by Base 45EC (T_5) (90.87%). In case of other treatments in decreasing larval infestation during the management of jute hairy caterpillar were 88.87%, 87.38%, 85.76%, 84.23% and 81.95% in Fusion 20SL (T_2) Hayron 5EC (T_4), Rescue 6WDG (T_3), Perfect 30WDG (T_6) and Emacto 5WDG (T_1) respectively. As a result, the order of efficacy in terms of decreasing the percent larval infestation is $T_7 > T_5 > T_2 > T_4 > T_3 > T_6 > T_1$.

Atwal & Dhaliwal, (1997) also found that Quinalphos 25 EC can also be used for the control of this pest which is signifying this result. Sidhu & Dhawan, (1980) also reported that quinalphos and endosulfan were good in controlling the larvae on Bihar hairy caterpillar. Mrig and Singh, (1981) observed that out of 18 insecticides tested only three insecticides namely quinalphos 0.075 percent, endosulfan 0.15 percent and dichlorvas 0.025 percent caused very high mortality of the 5 and 7 instars caterpillars all the intervals in both the experiments. Hence any one of these insecticides considering the availability, price, toxicity etc. may be used to control this insect which is similar to the present study.

4.2.2.3 Effect of different insecticides in controlling jute hairy caterpillar under field condition at Central station of BJRI during 2017

The experiment was conducted at Central station in Dhaka during 2017. The effect of different chemical insecticides on percent reduction over control of plant infestation by jute hairy caterpillar was determined in the field. Reults (Table 7.) indicated that after spray of 3rd day, all insecticides reduced considerable amount of plant infestation. The highest percent reduction of infestation (88.28%) was recorded in Mekalux 25EC treated plot followed by Base 45SP (84.60%), Fusion 20SL (83.83%), Hayron 5EC (83.19%), Perfect 30WDG (82.01%), Rescue 30 WDG (81.78%) which were statistically similar. The lowest reduction of infestation was (80.08%) recorded in Emacto 5WDG treated plot which was different from others. All insecticides were found effective for controlling jute hairy caterpillar giving more than 80% reduction of plant infestation.

In case of 7th days after treatment, the highest percent reduction of plant infestation (94.33%) was recorded Mekalux 25EC treated plot followed by Base 45SP (91.68%), Fusion 20SL (89.02%), Rescue 30 WDG (87.34%), Hayron 5EC(86.18%), Perfect 30WDG (85.44%) respectively. All insecticides were found effective for controlling jute hairy caterpillar giving more than 80% reduction of plant infestation.

It was reported (Anon. 2013) that Seven insecticides were evaluated against jute hairy caterpillar in the fields of Central station, Dhaka. Cure 40SL, Nice 45SC, Emazoate 5SG, Goldimida 20SL, Macgor 40EC, Procure 5SG and Thunder 70 WDG @ 1.85 L/ha, 250ml/ha, 1.5kg/ha, 750ml/ha, 1L/ha, 1.5kg/ha and 100gm/ha respectively were found effective against jute hairy caterpillar giving more than 82.80 percent reduction of infestation at 7 days after spray.

It was reported (Anon. 2015) that Seven insecticides were evaluated against jute hairy caterpillar in the fields of Central station, Dhaka and JAES, Manikganj. Laser 10WDG, Achamka Plus 6WDG, Chatfat 10WDG, Over 40%WDG, Comon 6%WDG, Fusion 20SL, Amber 40WDG, Rescue 6WDG and Aktic 24SC @ 750gm/ha, 250gm/ha, 750gm/ha, 750gm/ha, 250gm/ha, 500ml/ha, 75gm/ha, 250gm/ha and 750ml/ha respectively were found effective against jute hairy caterpillar giving more than 88.20 percent reduction of infestation at 7th days after spray.

Table 7. Field efficacy of selected insecticides against jute hairy caterpillar in the field of central station, Dhaka

Treatment	Dose/ha	No of caterpillar before spray	% reduction of insect over control after spray at	
			3rd Day	7th Day
T1	1.5kg	80.75	79.78 b	82.39 c
T2	500ml	93.25	83.83 ab	89.02 abc
T3	250g	87.25	81.78 ab	87.34 abc
T4	500ml	85.75	83.19 ab	86.18 bc
T5	250ml	93	84.60 ab	91.68 ab
T6	100g	79.75	82.01 ab	85.44 bc
T7	1.5L	77.75	88.28 a	94.33 a
T8	0	82.5	---	---
CV%	----	6.91	7.84	6.26
$Lsd_{(0.05)}$	----	---	8.41	7.09

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan‘s Multiple Range Test (DMRT).

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

From the above findings it revealed that in case of 3rd day after spray Mekalux 25EC (T_7) performed as the best treatment in decreasing larval infestation (88.28%) during the management of jute hairy caterpillar followed by Base 45SP (T_5) (84.60%). In case of other treatments in decreasing larval infestation during the management of jute hairy caterpillar were 83.83%, 83.19%, 82.01% and 79.78% in Fusion 20SL (T_2), Rescue 6WDG (T_3), Hayron 5EC (T_4), Perfect 30WDG (T_6) and Emacto 5WDG (T_1) respectively. As a result, the order of efficacy in terms of decreasing the percent larval infestation is $T_7 > T_5 > T_2 > T_4 > T_6 > T_3 > T_1$.

Again in terms of percent larval reduction over control respectively after 7th days of spray, highest larval reduction was observed in T_7 (94.33%) treatment followed by T_5 (91.68%) treated plots which was statistically significant among the treatments.

In terms of the lowest percent reduction of jute hairy caterpillar (82.39%) was recorded in T_1 treated plots during cropping season.

From the above findings it was revealed that in case of 7th day after spray Mekalux 25EC (T_7) performed as the best treatment in decreasing larval infestation (94.33%) during the management of jute hairy caterpillar followed by Base 45EC (T_5) (91.68%). In case of other treatments in decreasing larval infestation during the management of jute hairy caterpillar were 89.02%, 87.34%, 86.18%, 85.44% and 82.39% in Fusion 20SL (T_2), Rescue 6WDG (T_3), Hayron 5EC (T_4), Perfect 30WDG (T_6) and Emacto 5WDG (T_1), respectively. As a result, the order of efficacy in terms of decreasing the percent larval infestation is $T_7 > T_5 > T_2 > T_3 > T_4 > T_6 > T_1$.

Effect of quinalphos and endosulfan against this pest was also studied by Sidhu & Dhawan, (1980) and they stated that in dust formulation quinalphos was most effective with 90% mortality of the larvae after 24 hours of treatment.

Sidhu and Dhawan, (1980) tested four new insecticides i.e. quinalphos, monocrotophos, phenthoate and phosalone and they compared with endosulfan, fenitrothion were less effective.

Premsagar and Ramzon, (1983) reported that quinalphos found to be the best against *D. obliqua* under laboratory conditions, followed by endosulfan, dichlorvas and formothion as they proved to be less effective.

Sinha *et. al.*, (1984) tested thirteen insecticides against the grown up larvae too, endosulfan (0.07%) followed by chlorpyriphos (0.05%), dichlorvas (0.05%), fenitrothion (0.05%) and quinalphos (0.05%) gave relatively better performance. However, when treated larvae feeding upon untreated food, only quinalphos (0.05%) could be able to give better control of grown up caterpillar.

The above mentioned findings are also showing close or same result with these present findings.

4.2.2.4 Effect of insecticides on plant height, base diameter and Yield of jute as influenced by jute hairy caterpillar control under field condition at JAES, Manikganj during 2017

The effect of different selected chemical insecticides on Plant height, base diameter and fibre yield of jute as influenced by jute hairy caterpillar control under field condition at JAES, Manikganj is presented in the Tables 8, 9 and 10. Plant height, base diameter and yield of jute plant were significantly influenced for the application of chemical insecticides. At the time of harvest, the highest plant height was 394 cm recorded in Mekalux 25EC treated plot followed by Base 45SP (387.75 cm) and Fusion 20SL (378.60 cm) treated plot which was statistically similar. The lowest plant height 271.88 cm was recorded from untreated control plot which was statistically different from all other treated plots.

The highest plant base diameter 17.44 mm was recorded in Mekalux 25EC treated plot followed by Base 45SP (17.21 mm), Fusion 20SL (16.79 mm) treated plot which was statistically similar. The lowest base diameter was 12.75mm found in untreated plot which was statistically different from all other treated plots.

The highest fibre yield of jute 3.43 ton/ha was recorded in Mekalux 25EC treated plot followed by Base 45SP (3.37 ton/ha), Fusion 20SL (3.27 ton/ha) which was statistically similar. Application of the insecticides Rescue 6WDG, Hayron 5EC, Perfect 30WDG and Emacto 5WDG resulted in the yield of 3.11, 3, 2.82, and 2.72 ton/ha respectively. The lowest fibre yield of jute was 2.24 ton/ha in untreated plot which was statistically different from all other treated plots.

Table 8. Plant height of jute as influenced by jute hairy caterpillar control with insecticides at JAES, Manikganj under field condition

Treatment	Plant height(cm)
T1	328.63 b
T2	378.60 a
T3	343.75 b
T4	342 b
T5	387.75 a
T6	342.75 b
T7	394 a
T8	271.88 c
CV%	5.24
Lsd $_{(0.05)}$	26.85

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan‛s Multiple Range Test (DMRT).

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250 gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

From the above findings it was found that Mekalux 25EC (T_7) performed as the best treatment (394 cm) for highest plant height followed by Base 45SP (T_5) (387.75 cm), Fusion 20SL (T_2) (378 cm), Rescue 6WDG (T_3) (343.75 cm), Perfect 30WDG (T_6) (342.75 cm), Hayron 5EC (T_4) (342cm) and Emacto 5WDG (T_1) (328.63 cm). As a result, the trend of increasing the jute plant height is $T_7 > T_5 > T_2 > T_3 > T_6 > T_4 > T_1$.

Table 9. Base diameter of jute as influenced by jute hairy caterpillar control with insecticides at JAES, Manikganj under field condition

Treatment	Base diameter(mm)
T1	14.43 b
T2	16.79 a
T3	15.20 b
T4	15.41 b
T5	17.21 a
T6	14.83 b
T7	17.44 a
T8	12.75 c
CV%	4.80
Lsd $_{(0.05)}$	1.09

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan‘s Multiple Range Test (DMRT).

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250 gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

In case of Plant base diameter Mekalux 25EC (T_7) showed the best result (17.44 mm) followed by Base 45SP (T_5) (17.21 mm), Fusion 20SL (T_2) (16.79 mm), Hayron 5EC (T_4) (15.40 mm), Rescue 6WDG (T_3) (15.20 mm), Perfect 30WDG (T_6) (14.82 mm) and Emacto 5WDG (T_1) (14.43 mm). Thus the trend of result in terms of increasing the jute plant base diameter is $T_7 > T_5 > T_2 > T_4 > T_3 > T_6 > T_1$.

Table 10. Yield of jute as influenced by jute hairy caterpillar control with insecticides at JAES, Manikganj under field condition

Treatment	Yield(ton/Ha)
T1	2.73 e
T2	3.27 ab
T3	3.11 bc
T4	3 cd
T5	3.37 a
T6	2.82 de
T7	3.43 a
T8	2.24 f
CV%	5.19
Lsd $_{(0.05)}$	0.22

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan‘s Multiple Range Test (DMRT).

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250 gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

Again for the case of yield of jute fibre Mekalux 25EC (T_7) showed the best result (3.43 ton/ha) followed by Base 45SP (T_5) (3.37 ton/ha), Fusion 20SL (T_2) (3.27 ton/ha), Rescue 6WDG (T_3) (3.11 ton/ha), Hayron 5EC (T_4) (3 ton/ha), Perfect 30WDG (T_6) (2.82 ton/ha) and Emacto 5WDG (T_1) (2.73 ton/ha). As a result, the trend in term of increasing the jute plant height is $T_7 > T_5 > T_2 > T_3 > T_4 > T_6 > T_1$.

Polan *et. al.*, (2009) reported that eight different insecticides viz. Fenvet 20EC, Celcron 50EC, King Lamda 2.5Ec, Kalvin 85WP, Queenphos 25EC, Lavin 85WP, Emite 5WDG and Noknon 60EC were evaluated in the potted plants @ 500ml/ha, 550ml/ha, 1lit/ha, 1.5kg/ha, 1lit/ha, 500gm/ha, 1.5kg/ha and 1.7lit/ha respectively and found effective against jute hairy caterpillar infestation over control at JAES, Manikganj. Highest yield (3.41 ton/ha) was found in the plot treated with Celcron 50 EC which was statistically similiar with Queenphos 25Ec, Emite 5WDG, Noknon 60EC and Hayzinon 60EC. Lowest yield (2.7 ton/ha) was found in control plot that was statistically different from others.

4.2.2.5 Effect of insecticides on plant height, base diameter and Yield of jute as influenced by jute hairy caterpillar control under field condition at central station, Dhaka under field condition during 2017

The impact of jute hairy caterpillar control by chemical insecticides on Plant height, base diameter and fibre yield of jute is presented in the Table 11 and Table 12. These three parameters were significantly influenced by the application of insecticides. At the time of harvest, the highest plant height of 398 cm was recorded in Mekalux 25EC treated plot by followed Base 45SP (373.75 cm) treated plot which was statistically similar. The lowest plant height of 275.13 cm was recorded from untreated control plot which was statistically different from all other treated plots.

The highest plant base diameter 17.50 mm was recorded in Mekalux 25EC treated plot followed by Base 45SP (17.10 mm), Fusion 20SL (16.59 mm) treated plot which was statistically similar. The lowest base diameter was 12.34 mm found in untreated plot which was statistically different from all other treated plots.

The highest fibre yield of jute 3.40 ton/ha was recorded in Mekalux 25EC treated plot followed by Base 45SP (3.30 ton/ha), Fusion 20SL (3.12 ton/ha) which were statistically similar. Application of the insecticides Rescue 6WDG, Hayron 5EC, Perfect 30WDG and Emacto 5WDG resulted in the yield of 3.03, 3, 2.89 and 2.80 ton/ha respectively. The lowest fibre yield of jute was 2.13 ton/ha in untreated plot which was statistically different from all other treated plots.

Table 11. Plant height of jute as influenced by jute hairy caterpillar control with insecticides at central station, Dhaka under field condition

Treatment	Plant height(cm)
T1	331.25 c
T2	368 b
T3	351.38 bc
T4	348.38bc
T5	373.75 ab
T6	336 c
T7	398 a
T8	275.13 d
CV%	5.50
Lsd $_{(0.05)}$	28.11

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan‘s Multiple Range Test (DMRT).

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

From the above findings it was revealed that Mekalux 25EC (T_7) performed as the best treatment (398 cm) for highest plant height followed by Base 45SP (T_5) (373.75 cm), Fusion 20SL (T_2) (368 cm), Rescue 6WDG (T_3) (351.38 cm), Hayron 5EC (T_4) (348.38cm), Perfect 30WDG (T_6) (336 cm) and Emacto 5WDG (T_1) (331.25cm). As a result, the trend in terms of increasing the jute plant height is $T_7 > T_5 > T_2 > T_3 > T_4 > T_6 > T_1$.

Table 12. Base diameter of jute as influenced by jute hairy caterpillar control with insecticides at central station, Dhaka under field condition

Treatment	Base diameter(mm)
T1	14.25 d
T2	16.59 ab
T3	15.67 bc
T4	15.57 bcd
T5	17.10 a
T6	14.83 cd
T7	17.5 a
T8	12.34 e
CV%	5.99
Lsd $_{(0.05)}$	1.36

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan‘s Multiple Range Test (DMRT).

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

In case of Plant base diameter Mekalux 25EC (T_7) showed the best result (17.50mm) followed by Base 45SP (T_5) (17.10 mm), Fusion 20SL (T_2) (16.59 mm), Rescue 6WDG (T_3) (15.67mm), Hayron 5EC (T_4) (15.57 mm), Perfect 30WDG (T_6) (14.83 mm) and Emacto 5WDG (T_1) (14.25 mm). Thus the trend of result in terms of increasing the jute plant base diameter is $T_7 > T_5 > T_2 > T_3 > T_4 > T_6 > T_1$.

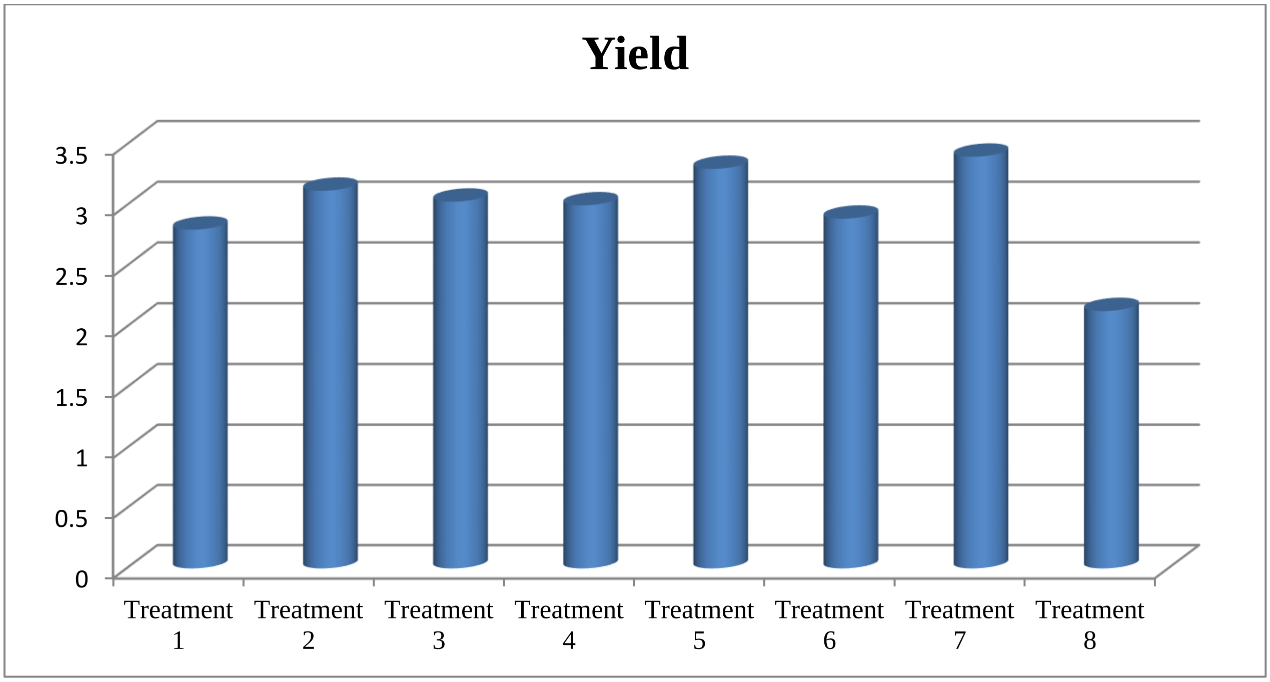

Figure 2. Effect of different chemical insecticides on yield of jute as influenced by jute hairy caterpillar

[T_1= Emacto 5WDG @ 1.5kg/ha, T_2= Fusion 20SL @ 500ml/ha, T_3= Rescue 6WDG @ 250gm/ha, T_4= Hayron 5EC @ 500 ml/ha, T_5= Base 45SP @ 250ml/ha, T_6= Perfect 30WDG @ 100gm/ha, T_7= Mekalux 25EC @ 1.5L/ha and T_8= Control.]

In case of yield of jute fibre quantity Mekalux 25EC (T_7) showed the best result (3.40 ton/ha) followed by Base 45SP (T_5) (3.30 ton/ha), Fusion 20SL (T_2) (3.12 ton/ha), Rescue 6WDG (T_3) (3.03 ton/ha), Hayron 5EC (T_4) (3 ton/ha), Perfect 30WDG (T_6) (2.89 ton/ha) and Emacto 5WDG (T_1) (2.80 ton/ha). As a result, the trend in terms of yield of the jute plant is $T_7 > T_5 > T_2 > T_3 > T_4 > T_6 > T_1$.

CHAPTER- V

SUMMARY AND CONCLUSION

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The biology includiing morphometric characters of different developmental stages, efficacy of different insecticides against jute hairy caterpillar, *Spilosomsa obliqua* were investigated.

Among the morphometric characters of jute hairy caterpillar, the eggs were round on upper surface and flattened at base. The newly hatched larva was whitish with shining brown head and brown spots over entire body from which white hair arise which later on turn black. The duration of first instar larva was 3 ± 0.25 days and the length and breadth was 5.24 ± 0.21 mm and 1.04 ± 0.06 mm. The second instar larva slightly increased in size having light yellow colour body with brown markings on thoracic and last abdominal segment. The duration of second instar larva was 5.5 ± 0.28 days and the length and breadth was 10 ± 0.43 mm and 2.57 ± 0.08 mm. Third instar larvae were similar to the second instar but the colouration of head and body segments were little dark. The duration of third instar larva was 8.41 ± 0.45 days and the length and breadth was 15.23 ± 0.42 mm and 3.99 ± 0.125 mm respectively. The fourth instar larvae were uniformly yellowish as the segments were brown and the head turned dark brownish black. The duration of fourth instar larva was 11.08 ± 0.37 days and the length and breadth was 24.92 ± 0.33 mm and 5.58 ± 0.11 mm respectively. The fifth instar larva was dark yellow with reddish tine in colour and the head and thoracic shields were dark brown in colour while the legs were found to be reddish brown. The duration of fifth instar larva was 16.66 ± 0.37 days and the length and breadth was 36.48 ± 0.16 mm and 6.64 ± 0.11 mm respectively. The fully grown sixth instar larva was of dark black head with brownish legs and uniformly reddish brown body with brownish black verrucae on which there were whitish hairs. The duration of sixth instar larva was 20.16 ± 0.32 days and the length and breadth was 43.57 ± 0.11 mm and 67.73 ± 0.066 mm respectively. The newly formed pupae were soft and pale brown in colour. Later on, the pupa turned brownish in colour.

The duration of pupa was 9.83 ± 0.42 days and the length and breadth was 17.45 ± 0.034 mm and 5.45 ± 0.013 mm respectively.

The adult moths were straw in colour with orange and brown streaks over the forewings and white streak along the anterior margin and reddish abdomen. The hind wings were found yellowish in colour with black markings. The length of adult male and female were 15.19 ± 0.045 and 15.74 ± 0.035 and the breath of adult male and female moths were 4.47 ± 0.014mm and 5.07 ± 0.010 mm respectively. The pre-oviposition and oviposition periods were 1.42 ± 0.15 days and 3.5 ± 0.29 days. The longevity of female and male moths was 7.41 ± 0.34 days and 3.42 ± 0.26 days respectively.

Seven insecticides were tested on potted plants against jute hairy caterpillar, *Spilosoma obliqua* for determining the effective dose of the chemicals. Emacto 5WDG @ 1.5 kg/ha, Fusion @ 500ml/ha, Rescue 6WDG @ 250/ha, Hayron 5EC @ 500ml/ha, Base 45SP @ 250 ml/ha, Perfect 30WDG @ 100gm/ha and Mekalux 25EC @ 1.5/ha gave more than 85% mortality of jute hairy caterpillar. Treatment T_7 with (Quinalphos: Mekalux 25EC) gave the best performance with more than 95% mortality followed by T_5 (Spinosad: Base 45SP). All selected dose of insecticides showed more than 80% reduction of plant infestation over control in both two locations Central station, Dhaka and JAES, Manikganj. The result of trial in two locations clearly indicates that all the insecticides were effective against jute hairy caterpillar. Plant height, base diameter and fibre yield of jute were influenced by the application of insecticides in the field.

The biology of jute hairy caterpillar provided information on the most damaging stage of this pest to undertake control measures. There are many synthetic insecticides available in the local market to control jute hairy caterpillar but all are not available in all over the country and all are not equally effective. The present study might help to include more number of chemical insecticides in the recommendation list, which will help the jute growers to overcome resistance problem of pest against insecticide.

CHAPTER- VI
REFERENCES

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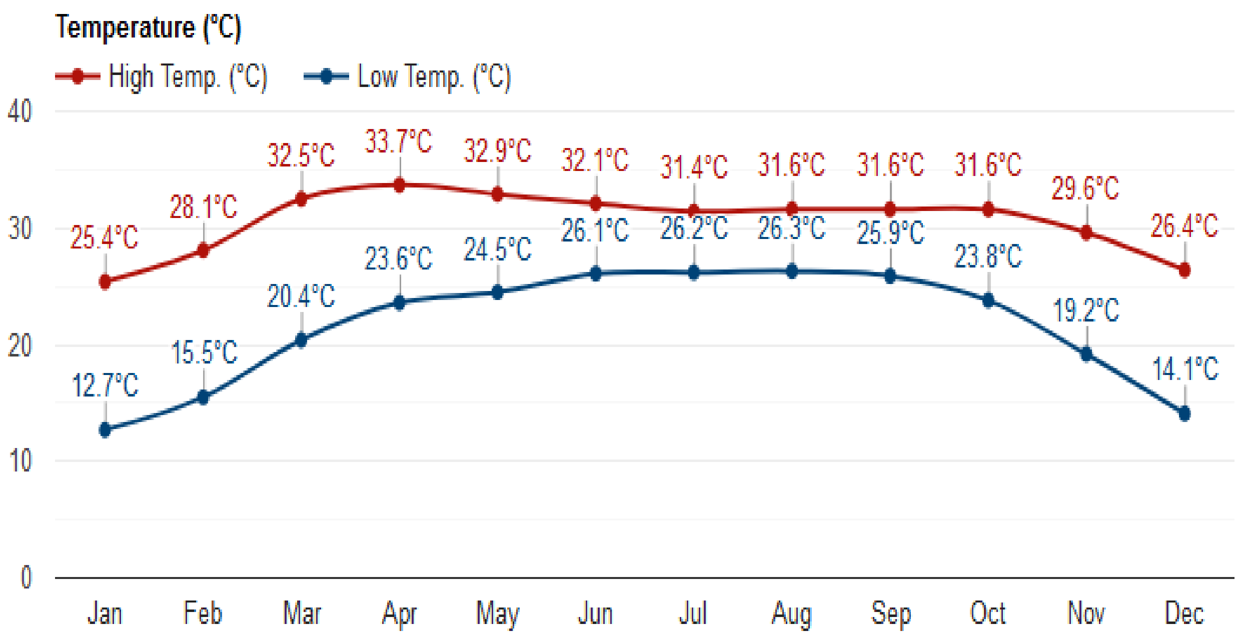
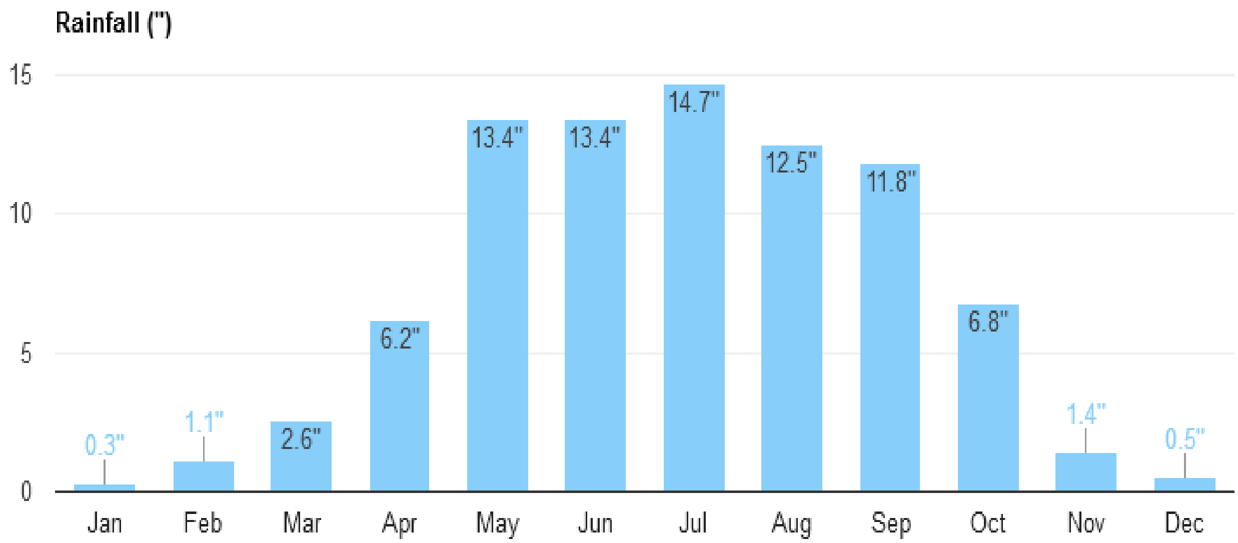
APPENDICES

Appendix I. Monthly record of air temperature (°C) of the experimental site during the period from JANUARY 2017 to DECEMBER 2017



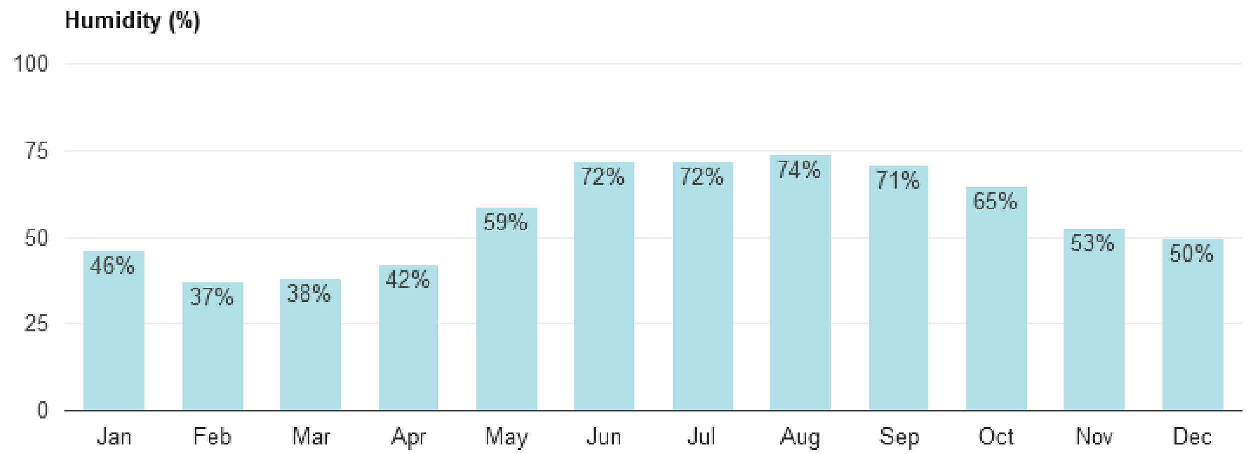
Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207

Appendix II. Monthly record of rainfall of the experimental site during the period from JANUARY 2017 to DECEMBER 2017



Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207

Appendix III. Monthly record of relative humidity of the experimental site during the period from JANUARY 2017 to DECEMBER 2017



Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207