# EFFECTIVENESS OF NEEM OIL AND SOME INSECTICIDES IN MANAGING TOBACCO CATERPILLAR, *SPODOPTERA LITURA* (FAB.) ON CABBAGE



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**JUNE, 2007**

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**REGISTRATION NO. 26170/00464**
**Semester: Jan-June/2006**


**A Thesis**

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka-1207
in partial fulfilment of the requirements for the degree of

**MASTER OF SCIENCE (M.S.)**
**IN**
**ENTOMOLOGY**



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|---|---|
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| Supervisor | Co-Supervisor |

**Jahanara Begum**
Chairman of the examination committee

# DECLARATION

I do hereby declare that this thesis entitled " **EFFECTIVENESS OF NEEM OIL AND SOME INSECTICIDES IN MANAGING TOBACCO CATERPILLAR, *SPODOPTERA LITURA* (FAB.) ON CABBAGE**" has been written and composed by myself with my own investigated research data.

I further declare that this thesis has not been submitted anywhere in any form for any academic degree.

Nur Muhammad

**June, 2007** **(Nur Muhammad)**

# *CERTIFICATE*

This is to certify that thesis entitled *"EFFECTIVENESS OF NEEM OIL AND SOME INSECTICIDES IN MANAGING TOBACCO CATERPILLAR, SPODOPTERA LITURA (FAB.) ON CABBAGE"* submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of *MASTER OF SCIENCE IN ENTOMOLOGY,* embodies the result of a piece of bonafide research work carried out by Mr. Nur Muhammad, Registration No. 26170/00464 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 been duly been acknowledged by him.

**Dated: June, 2007**
**Place: Dhaka, Bangladesh**

**Dr. Md. Abdul Latif**
**Supervisor**
**Advisory Committee**

Dedicated to

My

Beloved Parents

## ACKNOWLEDGEMENT

*The author is thankful and finds pleasure to express his deepest sense of gratitude to the Almighty Allah for his immense blessings upon him for the sound health and successful completion of M. S. Degree.*

*He expresses his sincere appreciation, profound gratitude and indebtedness to his supervisor Dr. Md. Abdul Latif, Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for planning, painstaking guidance, immeasurable help, continuous valuable suggestions, inestimable patience, criticism and encouragement throughout the research work to final preparation of this thesis.*

*Heart-felt gratefulness and abysmal respect are due to his co-supervisor, Md. Mizanur Rahman, Associate Professor, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka for his advice and suggestion during the research work and preparation of this thesis.*

*The author also feels proud to express his abysmal respect and indebtedness to Professor Jahanara Begum, Chairman, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, for her encouragement and constructive comments in preparation of the thesis.*

*Cordial thanks to Professor Dr. Md. Serajul Islam Bhuiyan, Professor Dr. Mohammed Ali and Md. Razzab Ali, Associate Professor, Department of*

*Entomology, Sher-e Bangla Agricultural University, Dhaka, for their valuable suggestions during the research work.*

*The author expresses his deepest respect and boundless gratitude to all the respected teachers and staffs of the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, for the valuable teaching, sympathetic co-operation and inspirations throughout the course of this study and research work.*

*Heartiest thanks and gratitude are due to Sher-e-Bangla Agricultural University Research System (SAURES) and Farm division of Sher-e-Bangla Agricultural University for their support to conduct the research.*

*Special thanks are made to Miss Sabera Yasmin for her encouragement and kind help in taking photograph.*

*All of intimate friends and well wishers who helped directly or indirectly during the research work and thesis writing are greatly acknowledged.*

*The author expresses his last but not least profound gratitude to his beloved parents and relatives for their inspiration, blessing and encouragement that opened the gate of his higher studies in his life.*

***June, 2007*** ***The Author***

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**EFFECTIVENESS OF NEEM OIL AND SOME INSECTICIDES IN MANAGING TOBACCO CATERPILLAR, *SPODOPTERA LITURA* (FAB.) ON CABBAGE**

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## THESIS ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University (SAU) farm during November to February, 2007 to evaluate the effectiveness of neem oil and six insecticides for the management of tobacco caterpillar, *Spodoptera litura* (Fab.). There were eight treatments comprising neem oil, Dursban 20EC, Marshal 20EC, Ripcord 10EC, Flubendiamide 24WG, Lebaycid 50EC, Actara 25WG and untreated control. Cabbage variety 'LAURELS-$F_1$ Hybrid' was used in this experiment. The experiment was laid out in Randomized Completely Block Design (RCBD) with 3 replications. Ripcord 10EC applied at seven days interval reduced 91.60, 86.48 and 86.68% infestation of leaf over control at early, middle and harvesting stage of head formation, respectively. Ripcord 10EC and Flubendiamide 24WG provided 89.98% reduction of tobacco caterpillar infestation over control. Neem oil also provided 70.01% reduction of tobacco caterpillar infestation of cabbage head by number over control. Both healthy and total yield were the highest in Ripcord 10EC (70.34 t/ha and 71.12 t/ha, respectively) treated plots. Similar healthy and infested yields were obtained (69.35 t/ha and 70.11t/ha, respectively) in Flubendiamide 24WG treated plots. Ripcord 10EC and Flubendiamide 24WG provide more than 80% reduction of yield loss over control. Ripcord 10EC reduced 88.39% bores per infested leaves while Flubendiamide reduced 86.05% bores per infested leaf. Both Ripcord 10EC and Flubendiamide 24WG reduced 92.38% larval population per infested head. There were highly negative correlations between percent leaf infestation and percent head infestation with yield of cabbage. The highest BCR (1.55) was obtained by the application of Ripcord 10EC at weekly intervals and almost similar BCR (1.49) was obtained by application of Flubendiamide 24WG.

# Chapter 1
# Introduction

# CHAPTER I

# INTRODUCTION

Cabbage, (*Brassica oleracea* var. *capitata* L.) locally known as 'Bhadha Kopi' or 'Pata Kopi', is a popular and most common winter vegetable crop in Bangladesh. It is one of the five leading vegetables, which is cultivated usually in Rabi season in our country. The cabbage *Brassica oleracea* var. *capitata* is grown as an important vegetable in many parts of the world. In 2003-2004, 129 thousand metric tons of cabbage was produced, which ranked fifth among the vegetables produced in Bangladesh (BBS, 2004). Among the five leading vegetables in Bangladesh, cabbage occupied an area of 11.33 thousand hectares of land with a total production of 142 thousand metric tons (BBS, 2005). In Bangladesh, the paddy field becomes converted to vegetables field day after day. It is seen especially near by the town and metropolitan city because the return is nearly three times higher than that of from the paddy. It is revealed that a farmer can easily grow 4035 cabbage in 33 decimals of land, which is quite encouraging task (Ramphall and Gill, 1990).

Head is the edible portion of cabbage, which is formed by the fleshy leaves overlapping one another. Cabbage is a leafy vegetable rich in vitamin C and tryptophan, an important amino acid for our body (Rashid, 1993). It has been reported that 100 g of green edible portion of cabbage contains 92% water, 24 calories of food energy, 1.5 g of protein, 9.8 g of carbohydrate, 40 mg of Ca, 0.6 mg of Fe, 600 IU of Carotene, 0.05 mg of thiamine, 0.05 mg of riboflavin, 0.3 mg of niacin and 60 mg of vitamin E (Rashid, 1993).

There are a lot of insect pests of cabbage that hamper the production and reduce its yield. Lee (1986) reported that tobacco caterpillar, *Spodoptera litura* (Fab.) was the most destructive pest among the nine insect pests of cabbage. Tobacco caterpillar, *Spodoptera litura* was one of the key insect pests of cabbage, which caused more than 50 percent reduction of cabbage yield in some cabbage genotypes (Ei-Tom, 1987). The cabbage caterpillar/tobacco caterpillar is also called Prodenia caterpillar, which destroys the leaves of cabbage by making holes in the head and greatly reduces its market value. Larvae bored the new forming head and reached to the newly emerging little leaf and consumed it. Sometimes it caused rotting in the inner portion of cabbage. The nature and extent of damage differed with age of the caterpillars. The young caterpillar along with mature caterpillar also caused greater damage if the infestation occurred at the head forming stage (Tofael, 2004).

The management practices of tobacco caterpillar are mostly limited to use of insecticides of different chemical groups such as organophosphates, synthetic pyrethroids and nicotinamides (Deng *et al.*, 2002; Sreekanth *et al.*, 2000; Kumar and Krishnaynya, 1999; Ramaprasad *et al.*, 1993; Peter *et al.*, 1987). Cabbage growers of Bangladesh also use various insecticides to control this obnoxious pest (Ali and Bakshi, 1994). Peter *et al.* (1987) reported that chlorpyriphos, carbaryl, parathion and BHC were the most effective insecticides in controlling tobacco caterpillar. Methomyl, alphamethrin and fenvelerate showed the highest efficacy against the tobacco caterpillar, *Spodoptera litura* and gave significantly higher yields of cabbage as compared with other insecticides (Ramaprasad *et al.* 1993). Pyrethroid lambda-cyhalothrin had the greatest toxicity at 24 and 48 h against *Spodoptera litura* (De Souza *et al.*, 1992). But cypermethrin was relatively more toxic than fenvelerate against different larval instars of *S.* litura (Rao *et al.*, 1996).

Reports are also available on the efficacy of neem products against the tobacco caterpillar (Devaki *et al.*, 2004; Chari *et al.*, 1999; Malathi *et al.*, 1999; Sharma *et al.*, 1999; Venkateswarly *et al.*, 1998). Neem leaf extracts reduced food consumption, growth and nutritional efficiency of tobacco caterpillar. It also extended larval and pupal durations and reduced longevity and fecundity of this pest (Kumar *et al.* 1997). Sharma *et al.* (1999) reported that neem oil markedly decreased feeding of *S. litura* (Fab.). Neem oil at 8 and 16% concentration exhibited complete repellent and antifeedant effect against larvae of *S. litura* (Fab.) on *Vigna mungo* leaves (Venkateswarly *et al.*, 1998). Neem oil at 1.5% concentration was found highly effective against *S. litura* (Fab.) on tobacco in the laboratory (Chari *et al.*, 1999).

Evidence suggests that all insecticides could not successfully control S. *litura* in the field. Moreover, they created many problems like excessive residues on market vegetables that concerns general consumer health and the environment, pesticide resistance, trade implication, poisoning, hazards to nontarget organisms, increased production cost etc. ( Debach and Rosen, 1991). As a result, pesticides companies are introducing new chemicals for the management of this obnoxious pest of cabbage. Flubendiamide is a new, unclassified chemical, which showed high efficacy against nine major lepidopterous insect pests including resistant strains in the laboratory (Tohnishi *et al.*, 2005). Careful and detailed investigations about the effectiveness of neem and new insecticidal chemicals against tobacco are essential. Field screening is one of the best process for selecting a new insecticide against the target pests. Keeping this perspective in view, the experiments on six insecticides selected from organophosphate, carbamate, synthetic pyrithroid, nicotinoid, unclassified groups and neem oil were undertaken against tobacco caterpillar in the field with the following objectives:

1. To compare the effectiveness of neem oil with some selected insecticides in controlling the tobacco caterpillar in the field.
2. To evaluate the effectiveness of neem oil for the management of tobacco caterpillar.
3. To find out the best insecticides for the management of tobacco caterpillar in the field.

# Chapter 2
# Review of Literature

# CHAPTER II

# REVIEW OF LITERATURE

Cabbage (*Brassica oleraceae* var. *capitata* L.) is an important vegetable crop in Bangladesh. Cabbage is infested by large numbers of insect pests in the field, which cause considerable yield damage in every year. Among them, tobacco caterpillar, *Spodoptera litura* (Fab.) is one of the most serious pests. Literatures cited below under the following headings and sub-headings reveal some information about this study.

## 2.1 General review of tobacco caterpillar

**Nomenclature:**

The tobacco caterpillar, *Spodoptera litura* (Fab.), belongs to the order Lepidoptera and the family Noctuidae.

**Common name :** Tobacco caterpillar

**Synonym** : Cabbage caterpillar or Prodenia caterpillar

**Order** : Lepidoptera

**Family** : Noctuidae

**Scientific name :** *Spodoptera litura* (Fab.)

## 2.2 Origin and distribution of tobacco caterpillar

The tobacco caterpillar is found throughout the tropical and subtropical parts of the world. It is wide spread in India (Atwal, 1986). This pest has been reported from India, Pakistan, Ceylon, Burma, Thailand, Malaysia, Cambodia, Laos, Vietnam, Sabah, Indonesia, the Philippines, Taiwan, Queensland, New South Wales, New Guinea,Papua, West Iran, Solomon Islands, Gilbert Islands, New Caledonia, Fiji, Samoa, Tonga, Society Islands, Gilbert Islands and Micronesia (Grist *et al.*, 1989).

Hill (1983) reported that *Spodoptera litura* (Fab.) is a polyphagous pest of cabbage and cauliflower. It is originated from South and eastern Old World tropics, including Pakistan, India, Bangladesh, Srilanka, S.E. Asia, China, Korea, Japan, The Philippines, Indonesia, Australia, Pacific islands, Hawaii and Fiji. The two old world cotton leaf worm species *Spodoptera litura* and *Spodoptera littoralis* are allopatric, their ranges covering Asia and Africa, respectively.

## 2.3 Nature of damage of tobacco caterpillar

Tobacco caterpillar, *Spodoptera litura* (Fab.) attacks the tender leaves, and only the larvae caused the damage. The female moth of cabbage caterpillar laid eggs on the lower surface of the leaves, the tiny caterpillar starts feeding on host plant. In the early stage of cabbage, caterpillars bored the new forming head and reached to the newly emerging little leaf and consumed it. As a result, many head of cabbage could not form and at that time it was not economical to replace it with another new seedling. Due to the cosmetic nature of cabbage, a hole is enough to devaluate it. In market it is sold in reduced price due to presence of excreta at the damaged site. Sometimes it caused rotting in the inner portion of cabbage. The nature and extent of damage differed with age of the caterpillars. The young caterpillar along with mature caterpillar also caused greater damage if the infestation occurred at the head forming stage. In field, later stage of cabbage was not found to be infested. Succeeding generations can do greater damage and later instar larvae remained outside the cabbage head, can come out as a serious phase of infestation for their voracious feeding habit (Tofael, 2004).

### 2.4 Pest status:

Lee (1986) in Taiwan investigated the pest's incidence of 9 insect's pests on cabbage and observed that *Spodoptera litura* (Fab.) was a serious pest occurred in the warmer months, September to December with peaks in November to December. In Bangladesh, tobacco caterpillar, *Spodoptera litura* (Fab.) was one of the key insect pests of cabbage and yield limiting factor of cabbage (Ei-Tom (1987). This pest caused more than 50 percent reduction of cabbage yield in some cabbage genotypes. *Spodoptera litura* (Fab.) was a serious pest of cabbage and cauliflower in Bengal.

Tobacco caterpillar, *Spodoptera litura* (Fab.) is one of the most destructive agricultural lepidopterous pests within its subtropical and tropical range. This caterpillar was essentially a leaf eater, but did occasionally like a cutworm. Heavy infestations resulted in severe defoliation but these were not of frequent occurrence. The young larvae were gregarious but they dispersed as they become older (Bhat *et al.*, 1984). Hill (1983) stated that tobacco caterpillar was not very frequently a serious pest on any one particular crop but had regular occurrence on different cruciferous crops like cabbage, cauliflower etc. European and Mediterranean Plant Protection Organization (EPPO) have listed *Spodoptera litura as on* A1 quarantine pest (OEPP/EPPO, 1979). Alam (1969) revealed that *Spodoptera litura* (Fab.) was a general and very destructive pest in agricultural crops.

## 2.5 Host range of tobacco caterpillar

Surekh *et al.* (2000), reared the tobacco caterpillar, *Spodoptera litura* (Fab.) in the laboratory for several generations using different weed and cultivated plant leaves as food. The larval food preference was castor (*Ricinus communis*) > tomato > tobacco > mulberry > brinjal > cabbage. Faster larval growth rate, shorter larval period and better survival were obtained with the first three preferred food plants. Temperature during rearing significantly affected the life cycle.

Hill (1973) stated that prodenia caterpillar a polyphagous pest of major status on cotton, rice, tomato, tobacco, cabbage and cauliflower, *Citrus*, cocoa, sweet potato, rubber, ground nut, castor, legumes, millets, sorghum, maize, and many vegetables. *Spodoptera litura* was a polyphagous insect known as a major pest of cotton, tobacco and tomato besides cacao, citrus, sweet potato, rubber, groundnuts, castor, soybeans, many other vegetable crops, millet, sorghum, maize and *Eleusine*.

Patel *et al.* (1987) found that larval survival of noctuidae was the highest (100%) on *Ricinus communis* and cabbage, followed by 94.2% on *Lablab purpureus*, 92.2% on leceme and 82% on *Coccinea grandis*. The duration of larval development was shorter on *R. Communis* (17.8 days) followed by Lucerne (22.5 days) cabbage (23.1 days) *L. purpureus* (25 days) and *C. grandis* (29.4 days). The growth index was highest on *R. communis* (5.75) followed by cabbage (4.33) Luceme (4.76) and *C. grandis* (2.79).

Apart from feeding on cabbage, the tobacco caterpillar had a very wide range of host plants, including herbaceous cultivated plants and weeds, chiefly amongst the

Cruciferae, Malvaceae, Leguminosae and Solanaceae. Tobacco caterpillar *Spodoptera litura* (Fab.) was widespread in India and, besides tobacco (*Nicotiana tabacum* L.), fed on castor (*Richinus communis* L.), ground nut (*Arachis hypogaea* L.), tomato, cabbage and various other cruciferous crops (Atwal, 1986).

Alam (1969) stated that the prodenia caterpillar fed on a very large variety of plants including tomato, cabbage, cauliflower, maize, potato, sweet potato, millet, ground nut, jute, tobacco, etc.

## 2.6 Biology of tobacco caterpillar

Subramanian *et al.* (2005) stated that the biology of *Spodoptera litura* varied significantly on seven cotton cultivars. Based on the developmental indices the susceptibility of cultivars to *S. litura* came in the following order LRA > MCU12 > SVPR3 > Surabhi > Sumangala > SVPR2 > MCU5. Higher protein and carbohydrate content of host plant had favourable influence on the growth and development; phenol and lipid content were maximum in LRA5166; phenol and lipid content restricted the development of insect. Carbohydrate and protein content were high in Sumangala, Surabhi and SVPR2.

The population dynamics of *Spodoptera litura* was studied by Zheng *et al.* (2005) to establish its continuous generation life table. The cumulative death rates of first, second, third, forth and fifth generations were 93.6, 98.5, 97.2, 99.1 and 99.99%, respectively. The indices of population trend of the first, second, third, and fourth generations were 17.41, 4.62, 5.63, and 0.55, respectively. This study determined development lasting periods of different metamorphosis for the first, second, third, forth, and fifth generations of *Spodoptera litura*. The emergence sizes and emergence periods of *Spodoptera litura* were predicted using the life table.

Soni *et al*. (2001) evaluated host preference of *S. litura* using castor, cabbage, and cauliflower as host plants. Results showed that the overall mean diameter of egg was 0.534 mm. The mean incubation period was significantly highest on cabbage (5.60 days) and the lowest on castor(3.40 days).Larval period, pre-pupal period were shortest on cauliflower (16.30,1.15 and 10.40 days, respectively). The average weight per larvae and pupae was the maximum on cauliflowers (1619.36 and 306.70 mg, respectively) and minimum on castor (1419.24 and 242.65 mg, respectively). Sizes of the full grown larvae and pupae were the maximum on cauliflower (34.83 mm and 17.10 mm length and 5.45 mm width) while, it was the lowest on castor (32.62 mm length and 5.05 mm width). Cauliflower recorded the highest wing span and body length of adult female (34.41 and 17.32 mm) and male (32.18 and 15.55 mm). The percentage of larval survival, pupation and adult emergence were also highest on cauliflower (94.00, 85.10 and 92.50%, respectively), whereas the longevity of female and male moth was recorded on cabbage (8.20 and 7.05 days, respectively), and minimum on castor (6.09 and 5.06 days, respectively. Similarly, the highest fecundity of female was recorded on cabbage and lowest on cauliflower (557.06 and 397.63 eggs, respectively). The highest growth index value (5.22) was recorded on cauliflower and lowest in castor (3.54).

Kharub *et al*. (1993) observed that a peak larval population of *S. litura* on the ground nut cultivar MH4 (Spanish bunch) appeared after 41 weeks. The maximum (38.8°C) and minimum (18.6°C) temperature and 61% RH were conducted for the development of larvae of *S. litura* under field conditions. They also found that at 28 ± 2°C in an incubator, *S. litura* completed sixth instar in 3.0, 3.7, 5.5, 4.6, 4.1 and 5.6 days respectively. The male and female pupal period was 8.6 and 8.4 days, respectively. Males survived for 8.8 days and females for 9.7 days. Copulation took place during the night, 3 to 5 times in a lifetime. The female laid an average of 1618.8 eggs (81.82% hatchability) in 12 egg masses in a period of 4.0 days. The incubation period was 3.0 days. In a normal population, the sex ratio (male: female) was 1:0.76.

Kumar *et al.* (1992) stated that the egg stage duration of the noctuid *S. litura* on sunflower in the laboratory was 3 days in May-June and 5.4 days in October. The average duration of the larval stage was 15.09 days in June and 16.67 days in October. Larval survival varied from 72 to 92% in May- October. The duration of the pupal stage lasted 7.49 days in September and 12.26 days in October. The adult life span ranged from 4.1-6.2 days in males and 5.1-7.8 days in females. Studies at constant temperature of 20, 25 and 30°c showed the egg stage last for 5, 4 and 3 days, respectively. Patil *et al.* (1991) observed that females of *Spodoptera litura* (Fab.) laid 536-1250 eggs and the egg, larval, pre-pupal and pupal stage in laboratory conditions (29.5 ± $2^0$C, R.H. 80±5%) on rice (variety java) lasted 3-4, 11-21, 1-3 and 9-11 days, respectively. .

Singh *et al.* (1989) studied the biology of *Spodoptera litura* (Fab.) at 28.9 – 31.5$^0$C and 65.3 – 73.3% R.H. The duration of larval stage varied between months being 29.3 days during August and 11.8 days during September. Survival of larvae was lowest (31.8%) during August and highest (92%) during September pupal development took 6-9 days.

The pre-oviposition and oviposition period varied from 2 to 4 days and 1 to 4 days respectively. The ration of males to females was 1:2.

Sanjrani *et al.* (1989) in Pakistan studied the effect of temperature on the biology of *S. litura* (Fab.). They found the highest fecundity and fertility of eggs (1034 eggs and 100% respectively) at average temperature of 19.55$^0$C and the lowest fecundity and fertility of eggs (387.4 eggs and 45.2%) at 34.9$^0$C. The shortest duration of life cycle (26.6 days) was also found.

In India, Patel *et al.* (1986) observed that the incubation period averaged 4.80± 1.68 days and hatching percentage was 87. Mean duration of larval period was 18.64 ± 2.75 days. Larva pupated in soil at a depth of 2 to 5 cm and pupal period varied from 7 to 11 days with an average of 8.12 ± 1.41 days. Longevity of males was averaged 6.30 ± 2.49 days whereas that of females was averaged 12.30 ± 3.16 days. Male to female sex ratio was 1: 0.67. The study was conducted form December to January when maximum and minimum temperature varied from 21$^0$C to 28$^0$C and 2$^0$C to 12$^0$C, respectively. They observed that the incubation period was 4.80 days in average and 87% of egg hatched on cotton. The five larval instars were averaged 3.12, 2.60, 2.80, 3.68 and 2.80 days in turn. The total larval period was average 18.64 days. The pupal period lasted 9-11 days with averaging 8.12 days. The male and female life span was averaged 6.30 days averaging 41.90 days. The pre-oviposition, oviposition and post-oviposition period were averaged 1.60, 7.60 and 3.10 days, respectively. The number of eggs laid by a single female was 2507- 3467 with averaging 3032 and number of egg masses were 10-16 with averaging 12.80.

In Bangladesh, Das (1985) studied the development of *Spodoptera litura* (Fab.) on four hosts. Larvae of the pest failed to complete their development on maize leaves. Mean larval duration differed significantly on sweet potato (13.67 days), cabbage (15.47 days), and groundnut (17.73 days). Other characteristic did not differ significantly.

Dhandapani *et al*. (1985) in India observed the rate of multiplication of *Spodoptera litura* (Fab.) on banana (*Musa sp*.). The population increased with and infinitesimal rate of (rm) 0.1525 and finite rate (lambda) of 1.165 females per female per day and a generation was completed in 40-48 days.

In The Philippines, Torreno (1985) found that the total development period of *S. litura* (Fab.) was 33 days. Eggs were laid in mass and incubation period was 2-3 (2.92 ± 0.03) days. Larval stage lasted for 18.5 to 17 days in six, some times five (34%) moults. The first stadium took three to four days and continued to moult every other day until full grown with a total feeding period of 16.5 days. Pupation ranged from 2 to 3 (2.18±0.04) days. Females had 9.6 days pupation period and from that of male it was 2 days sooner. Length of pupa did not differ between sexes but female seemed heavier the male. The sex ratio of 1:1 was recorded.

Urs *et al*. (1974) reared *S. litura* (Fab.) on semi synthetic diet and found that the larval stage lasted 16-19 days and the pupal stage 11-13 days at room temperature and total life cycle from eggs to adult lasted 31-35 days. Larvae and pupae reared on this diet were heavier than those reared on the leaves of castor (*Recinus communis*).Yushima *et al*. (1973) in Japan observed that *S. litura* (Fab.) became an important pest of vegetables crop in south-western Japan. They also found the peaks of adult emergence and pairing occurred 1-2 after sunset or lights off and the more than 80% of adults paired before midnight. Age was an important factor for pairing success and female became mature somewhat more quickly than the male the percentage of adult paired was 63.2 when the adult of the both sexes were two days old and more than 90% when both sexes were 3-4 days old.

Fujiie *et al.* (1973) studied the pairing and laying of *Spodoptera litura* (Fab.). He found the mating activities reached at peak during the night; there was no mark duration of male mortality. The numbers of eggs fertilized were constant. Female that had paired successfully laid most of their eggs during the night following that on which pairing occurred, virgin female laid most of their eggs on the fifth night following the start of experiment.

Nakamura (1973) in Japan observed that *Spodoptera litura* (Fab.) laid large Number of eggs on the first two days emergence than on subsequent days within the 18-30$^0$C. Females laid almost all their eggs by seventh day. Virgin female laid more egg masses but fewer eggs than female that had paired. Male can pair more than once but avoid female that had already paired.

Omino *et al.* (1973) studied the day night behavior of noctuidae in the laboratory in Japan at 25$^0$C and 16 hours photoperiod. Observation was made on phototaxis. All of *S. litura* (Fab.) remained on the leaf except the last. Sixth (last) instar larvae entered the vermiculite just before pupation. The responses of the species to light were similar to those of *Mamestra brassicae*. The first to fourth instar larvae of *M. brassicae* remained on leaf and the fifth and sixth entered the vermiculite. They found that larvae in the first two instars showed positive phototaxis and those in the last showed negative phototaxis.

Nasr *et al.* (1966) in Egypt observed the abundance of *S. litura* (Fab.) on the leaves, Squares and bolls. He also observed larval color influenced by the food. The larval and pupal stage were shorter on cotton flowers (20.1 days and 9.85 days) then the cotton leaves (22.5 days and 11.28 days) or sweet potato leaves (21.28 days and 10.26 days) but female reared as larvae on sweet potato laid higher average number of eggs (1517) then those on cotton flower (1196) or leaves (720). Adults from larvae reared on cotton flowers lived for an average 7.22 days, those on cotton leaves for 6.33 days and those on sweet potato for 7.91 days.

Hassan *et al.* (1960) in Egypt studied the behavior of adult and the larvae of *Spodoptera litura* (Fab.) He found that after hatching larvae aggregate at the site of hatching for a short time and then dispersed by crawling and by means of silken threads. Comparatively cool and humid condition at night induced movement and feeding activity by the larvae and flight by the adults. The most emerged at night mostly between 9 and 10 pm. approximately 80 percent of them rested during the day and feeding took place shortly before sunrise. Most of adult mated on night of emergence and about 50% of mated females laid their eggs on the same night.

## 2.7 Monitoring

Larva can be found on the insides of heads. Pupation occurs at the top position under surface of the leaf making a silken coccon prepared with the body skin and sometimes uneaten pieces of leaves adhered to it. Pupae tend to move sideways when disturbed.

Adults can fly readily. Use a net to catch adults for identification. Both pupa and adults follow an aggregated distribution (Ahmed, 2004).

## 2.8 Influence of temperature on biology of tobacco caterpillar

Chu *et al.* (1989) in Taiwan gave an account on adult emergence and mating behavior of the noctuid. *Spodoptera litura* (Fab.). He observed that the majority of females emerged 1 hour after dark with males emerging 4-5 hours after dank at $25^0$C and 75-5% R.H. and LD 13.11. Mating for one pair occurred mostly between 20.00 and 21.00 h with the minor peak observed between 18.00 h to 19.00 h and 23.00 h to 24.00 and lasted 25 to 179 minute with an average of 92 minute. When one female was kept with 3 males, mating occurred mostly between 19.00 and 21.00 h. The copulation rate of the female was 100% and mating lasted for 50 to 260 minute. When 1 male was kept with 3 females mating occurred mostly between 18.00 and 19.00 h. The copulation rate of males was 90% and mating lasted for 52 to 208 minute for the first copulation and for 24 to 58 minute for the $2^{nd}$.

In Taiwan, Chen (1984) observed variation in the length of life cycle of *Spodoptera litura* (Fab.) on soybean, cauliflower and taro leaves at $25^0$C and $30^0$C with photoperiod of LD 12:12. According to his report the time required to complete the life cycle depended on temperature as well as food. Development from egg to 50% emergence at $25^0$C and $35^0$C temperature took 34-41 days and 25-28 days respectively. Age at initial oviposition was 27-35 and 20-26 days. Development took longer on soybean than cauliflower or taro.

In Taiwan, Chen *et al.* (1982) observed the influence of the temperature on larval development and leaf consumption of larvae of *Arotieia rape crucivors* (Boisd.) *Trichoplusia ni* (Hb.) and *Spodoptera litura* (Fab.) on cauliflower. They reported that the temperature requirement of 3 species was 258 day degree above a development threshold of $5.8^0$ C, 203 day degrees C above $9.8^0$C and 261 day degrees C above $10.9^0$C respectively. The mean leaf area consumption by larvae of 3 species at 15-25°C was 58.9, 86.0 and 310.0 $cm^2$ and relative efficiency of food utilization was found to be 2.30, 2.16 and 1.0.

## 2.9 Management practices

### 2.9.1 Effect of mechanical control on tobacco caterpillar

Abdul-Nasr *et al.* (1966) worked in Egypt and reported that the collection and destruction of egg masses of *Spodoptera litura* (Fab.) was a valuable control measure. They also said that the shape and size, placement of egg masses varied in the field. The masses varied widely in shape but square ones predominant at Gize and oval ones at Sakha. The egg masses contained 13-633, 94-1023 and 116-1698 eggs each and were laid almost at the lower surface of the leaf.

### 2.9.2 Effect of chemical control on tobacco caterpillar

#### 2.9.2.1 Effect of botanical insecticides

The repellent, antifeedant and ovicidal properties of the extracts of *Acorus calamus* , *Croton oblingifolis, Strychnos nux-vomica, Santalum album, Simarouba glauca* [*Quassia simarouba*] and *Vitox negundo* against *Spodoptera litura* infesting vegetables in Bangalore, Karnataka , India were determined under laboratory conditions by Murthy *et al.* (2006). All the extracts exhibited repellent, antifeedant and ovicidal properties, with *Acorus calamus* and *V. negundo* exhibiting the highest biological properties, regardless of the concentration.

Ghatak *et al.* (2005) conducted an experiment in West Bengal, India to investigate the biological efficacy of indigenous plant products in controlling *S. littoralis*. Petroleum ether extracts from seeds of *Pachyrhizus erosus* (PE) and *Annona squamosa* (AS) at I, 2 and 3% concentration; Neem plus 1500 ppm at 0.5, 1 and 2% concentration; and Monocil 36 SL [monocrotophos] at 0.03, 0.05, and 0.07% concentration were sprayed on third instar larvae of *S. littoralis*, and effects were assessed at 12, 24, 48, 72 and 96 h after treatment. Larval mortality under PE, AS and neem was 40.00-83.33, 46.66-70.00 and 40.00-60.00, respectively after 96 h treatment. Larval mortality due to monocil was 76.66-86.66 even at 48 h after treatment. Based on $LC_{50}$ values, monocil was the most toxic pesticide, while seed extract of AS was the least toxic.

Sharma *et al.* (1999) conducted and experiment for the effect of host plants like castor (*Ricimus communis*), cabbage, cauliflower, tomatoes and wild cabbage and also the effect of neem oil on food utilization indices of *S. litura*. They stated that, cauliflower was the most preferred host. Neem oil markedly decreased feeding by *S. litura* larva on these plants.

Neem oil (*A. indica*) at 8 and 16% exhibited complete repellent and antifeedant effect against larvae of *S. litura* on *Vigna mungo* leaves. At 0.5-4% repellency and antifeedant activity increased with increasing concentration. Neem oil at 0.5 and 1.0% lost its antifeedant property after 5 days (Venkateswarly *et al.* 1998).

Kumar *et al.* (1997) investigated the effect of exudates from reddish terminal leaves of neem, *Azadirachta indica* on *Spodoptera litura*. A significant increase in the larval mortality, antifeedancy and ovipositional repellency was found after treatment with acetone extracts of neem leaf exudates to fifth instar larvae. Reduced consumption, growth and nutritional efficiency were evident. Extended larval and pupal durations and reduced longevity and fecundity were observed by neem leaf extract treatment.

The repellency, antifeedant activity and development period increased with increase in concentration of biosol, neemark, repelin and neem oil. Moreover, adult emergence, growth, survival, larval and pupal weight, number of eggs laid and hatchability of eggs decreased with increase in concentration and neem oil had the greatest effects, followed by neemark, biosol and repelin (Rao *et al.* 1993).

Kaul (1987) determined dose response relationship of *Calamus* oil using food acceptance, feeding ratio, weight gain and larval development as parameters in choice tests against *S. litura*. At concentrations of 0.5% and 1.0% *Calamus* oil was effective in both tests inducing a significant reduction in feeding and inhibition of growth in early 3rd instar larvae. Neem oil had such effect only at 2%, particularly in no choice tests.

#### 2.9.2.2 Effect of chemical insecticides

A field study was conducted in Pantnagar, Uttaranchal, India, during the 2001 and 2002 kharif seasons, by Kuldeep *et al.* (2005) to determine the efficacy of different rates of insect growth regulators (IGRs) to manage the tobacco caterpillar, *Spodoptera litura*, infesting soybeans, compared to 800 ml monocrotophos/ha. The treatments comprised: 200; 300; 400; and 600 g/ha diflubenzuron/ha and 200; 400; 600; and 800 ml

Lufenuron/ha. The insect population decreased significantly compared to the control due to the use of IGRs and was at per with monocrotophos. The larval population was effectively suppressed on the third, seventh and tenth day after the second Spraying. Diflubenzuron at 600 g/ha was the most effective treatment in suppressing the defoliator population followed by 400 and 800 ml Lufenuron/ha.

Devaki *et al.* (2004) conducted an experiment in combination of *Bacillus thuringiensis* formulations viz., Dipel 8L, Delfin WG and Halt WP with neem products Viz., neem EC, NSKE and neem oil at their $LC_{50}$ against third instar larvae of *Spodoptera litura* (84.5 to 89.5) compared to NSKE (71.2 to 72.5) and neem oil (66.0 to 69.0) and found that the percent feeding inhibition resulted by the *B. t.* formulations and neem products ranged between 30.6 to 32.4 and 22.2 to 23.2, respectively. All *B. t.* formulations in combination with neem EC recorded maximum percent feeding inhibition in the range of 46.9 to 52.4.

Sudhakar *et al.* (2004) studied on the susceptibility of different larval instars of *Spodoptera litura* to chemical and microbial insecticides and found that a progressive increase in the tolerance with advancing instar, as higher concentrations are required for mortality. Low slope values of the log-probit regression equations with microbial insecticides suggest a greater degree of variability in the population. Also, the time required for 50% mortality increased with increase in the age of the larvae, except with some microbial insecticides.

Deng *et al.* (2002) tested the insecticidal activity of acetaniprid [acetamiprid] on seven species of insects was studied. The mortality rate of third instar larvae of cabbage butterfly [*Pieris brassicae*] treated with a solution of 3% acetaniprid $EC_{50}$ was 93.33%. Acetaniprid is a fine insecticide in controlling cruciferus leaf beetle, cabbage butterfly and tobacco caterpillar with high insecticidal activity on the two species of insects.

Sreekanth *et al.* (2000) stated that profenofos 0.05% exerted superior control of leaf webber [*Crocidolomia pavonana*] (98.14%) and tobacco caterpillar, *Spodoptera litura*, (80.06%) of cabbage, while imidacloprid 0.02% effectively suppressed diamond-back moth, *Plutella xylostella*, (67.76%). Deltamethrin + triazophos offered good control of leaf webber (97.22%) and tobacco caterpillar (65.07%). Silafluofen (non-ester pyrethroid) reduced the leaf webber population to an extent of 90.75%. Monocrotophos recorded 97.22% reduction of leaf webber. Under laboratory bioassay, profenofos 0.05% and deltamethrin + triazophos 0.075% caused 100 and 93.33% mortality of tobacco caterpillar respectively and profenofos 0.05% and diafenthiuron 0.025% registered 88.66 and 82.33% mortality of diamond back moth respectively, 24 hours after the treatment. The test insecticides were found to be toxic to the coccinellid predators in the following order: profenofos 0.05% = deltamethrin + triazophos 0.075% > silafluofen 0.02% > monocrotophos 0.05% > imidacloprid spray 0.02% > dichlorvos 0.1% > imidacloprid root dip 0.008% > diafenthiuron 0.025%.

Chari *et al.* (1999) conducted an experiment in the laboratory and nursery against tobacco caterpillar, *S. litura* during the year 1994 and 1995 seasons. They found that all the neem extracts were significantly more effective against *S. litura* on tobacco than *Pongamia* treatments. Neem oil at 1.5% conc. was found highly effective and at par with 2% NSKS (Neem Seed Kernel Extract Suspension). Chlorpyrifos and CTRI-III

Neem extract, *Pongamia* CTRI-III (*Pongamia* oil 1.5%) and alcoholic extract of neem without oil (CTRI-IV) at 50 ppm were the next best treatments. Further it is evident that alcoholic extract with neem oil provided better protection than without oil.

Kumar and Krishnaynya (1999) conducted a field experiment to determine the efficacy of diflubenzuron individually and in combination with buprofezin, methomyl chlorpyrifos, triazophos, profenofos and neem oil against major lepidopteran pests of groundnut like *Aproaerema modiella, S. litura* and *Helicoverpa armigera*. They found that neem oil (1.0%) treatments at 2 days resulted in 52.9, 30.7 and 39.9% larval population reduction of *Aproaerema modicella, S. litura* and *Helcoverpa armigera*, respectively.

Malathi *et al*. (1999) tested different formulations of *Bacillus thuringiensis* subsp. kurstaki (Dipel, Delfin, Biobit, Biolep, Bioasp), botanical insecticide neemgold, the nematode formulation (*Steinernema feltiae*) Green commandos and endosulfan against lepidopterous pests of cabbage under field conditions in Andhra Pradesh, India. Delfin was very effective in reducing the populations of cabbage leaf webber *Crocidolomia binotalis* Zell. [*Crocidolomia pavonana*] (64.69%) and diamondback moth *Plutella xylostella* L. (55.40%). Dipel was equally effective against these pests and recorded 64.54% and 54.38% reduction, respectively. Endosulfan proved to be effective against tobacco caterpillar *Spodoptera litura* (Fab.), which recorded a 53.42% reduction. All the tested insecticides were found to be safe and did not show any adverse effect on coccinellid populations under field conditions.

Babu and Krishnaynya (1998) tested the efficacy of quinalphos at 250 a.i. /ha, cartap at 500 g a.i./ha, neem oil at 1.0%, *Bacillus thuringiensis* sub sp. *Kurstaki* at 0.15% alone and in combination half the recommendation concentration for the control of *S. litura, Plutela xylostella* and *Crocidolomia binotalis* on cauliflowers. They found that, cartap and quinalphos and their combinations were highly effective and required fewer sprays (2 to 3) at much longer intervals (12 to 15 days). Neem oil, *Bacillus thuringiensis* subsp. *Kurstaki* and their combinations with other insecticides were relatively less effective but superior to the untreated control.

Singh *et al.* (1998) determined the relative susceptibility of 3rd instar larvae of *Spodoptera litura* Fab. against some pyrithroid and non-pyrithroid insecticides by bioassay method and compared with 2nd instar larvae of *Spodoptera litura*. On the basis of $LC_{50}$ value, the order of toxicity of different insecticides was bulldock> bifenthrin> decamethrin> cypermethrin> lambda-yhalothrin> chlorpyriphos> fenvelerate> malathion > lindane >endosulfan. The 2nd instar larvae were 25.7, 1.6, 1.3, 1.6, 2.2, 6.3, 2.7, 2.3, 0.7 and 0.9 times more susceptible to lambda-cyhalothrin, bulldock, decamethrin, cypermethrin, chlorpyriphos, fenvelerate, malathion, endosulfan, Bifenthrin and lindane than the 3rd instar of larvae of *S. litura*.

Jaglan *et al.* (1996) evaluated the persistence and residual toxicity of laboratory prepared emulsions of synthetic pyrethroids along with their proprietary formulations was evaluated against 9 + or 1-day old larvae of *Spodoptera litura* reared on treated castor beans [*Ricinus communis*] and cabbages. In the case of *R. communis*, considering the $LT_{50}$ and PT values, decamethrin [deltamethrin] + toluene + Triton X-100 exhibited maximum residual toxicity of 19.63 days, followed by proprietary deltamethrin (17.75 days). The $LT_{50}$ values for formulated cypermethrin, fenpropathrin and fenvalerate were 15.58, 13.23 and 11.95 days in comparison to their corresponding proprietary products, i.e., 16.32, 16.36 and 17.64 days, resp. In the case of cabbage, proprietary fenpropathrin registered maximum residual toxicity, being 23.70 days followed by deltamethrin + toluene + Triton X-100 (20.45 days). The descending order of residual toxicity in the case of cabbage was fenpropathrin proprietary, 23.703 days; deltamethrin + toluene + Triton X-100, 20.45 days; decamethrin proprietary, 20.17 days; cypermethrin + xylene + Triton X-100, 19.12 days; fenvalerate proprietary, 18.92 days; fenvalerate + C-IX + Tween-80, 17.81 days; cypermethrin proprietary, 17.65 days; and deltamethrin + toluene + Triton X-100, 16.85 days. Rao *et al.* (1996) observed that $LC_{50}$ values increased gradually from the first to fourth instar and cypermethrin was relatively more toxic than fenvelerate against different larval instars of *S. litura*.

Ali and Bakshi (1994) conducted an experiment, where different management strategies for *Plutella xylostella* and *Spodoptera litura* were evaluated on early and late crops of cabbage. Spot applications and 10% damage threshold sprays with cypermethrin at 1 ml/litre water or 0.6 litre/ha were compared with the existing fortnightly calendar-based fixed sprays of cypermethrin and thuricide (*Bacillus thuringiensis* subsp. *kurstaki*) at 1 ml/litre water or 0.6 litre/ha in controlling the pests. Insecticide sprays significantly reduced the percentage of plant infestation. The existing farmers' practice of calendar-based blanket sprays of both the chemical and microbial pesticide treatment was not cost effective. The spot application technique was economically as profitable as the fixed spray system. The damage threshold spray treatment required the least number of blanket sprays in both early and late crops of cabbage with no loss of marketability. The cost/benefit ratio was highest in this treatment and was most cost effective. A 10% visual damage of cabbage plants is thus suggested as a spraying threshold for the management of *P. xylostella* and *S. litura* in Bangladesh.

The relative efficacy of fluvalinate (0.016%), alphamethrin(0.0036%), fenpropathrin (0.009%), fenvelerate (0.01%), methomyl (0.038%) and chlorpyriphos (0.027%) was studied against the Tobacoo caterpillar, *Spodoptera litura* by Ramaprasad *et al.*(1993). Methomyl, alphamethrin and fenvelerate treated plots gave significantly higher yields of cured leaf as compared with other insecticides.

De Souza *et al.* (1992) stated that the pyrethroid, lambda-cyhalothrin had the greatest toxicity at 24 and 48 h against adult male *Spodoptera litur*a on cotton leaves sprayed at 500 μg/ml showed that 10-s exposure of adult male moths to surface residues resulted in appreciable knockdown within 30 M. At 1000 μg/ml, marked disruption of mating was observed for 7-14 after exposure under simulated field conditions.

Neem oil at 1.00% in combination with endosulfan 35 EC at 0.07% was the most effective in reducing infestation of *S. litura, Maruca testualis* ann *Helicoverpa armigera* and increasing black gram yields. The corresponding ratios for 0.5% neem oil, 1.0% neem oil, 1.0% neem oil + 0.07% endosulfan and 1.0% neem oil + 0.04% monocrotophos were 1:0.79, 1:0.50, and 1:0.49 respectively. For all treatments, 2 applications at 15 day intervals were better than 3 at 10 day intervals (Venkateswarlu *et al.*, 1992).

Peter *et al.* (1987) noticed that chlorpyrifos, carbaryl, parathion and BHC produced 100 percent mortality of the first instar larvae of *Spodoptera litura*, when exposed to the treated leaves one hour after dusting. The maximum period of persistence was obtained with chlorpyrifos (7 days) followed by carbaryl and parathion. Insecticides, chlorpyriphos, carbaryl, monocrotophos, fenitrothion and DDT recorded the $LC_{50}$ values in the ascending trend in the order of their efficacy against *Spodoptera litura*. Among the combination of insecticides in the high order of efficacy were Chlorpyriphos + fenitrothion, Chlorpyriphos + Carbaryl, Monocrotophos + Carbaryl, Monocrotophos + DDT. High susceptibility of second instar larvae was recorded with Carbaryl (9.48) followed by Chlorpyriphos (8.98) and Chlorpyriphos + Fenitrothion (2.29).

# Chapter 3

# Materials and Methods

# CHAPTER III

# MATERIALS AND METHODS

The experiment on the comparative effectiveness of neem oil with some insecticides against tobacco caterpillar, *Spodoptera litura* (Fab.) was carried out on cabbage variety of LAURELS ($F_1$ Hybrid) at Sher-e-Bangla Agricultural University (SAU) Farm, Sher-e-Bangla Nagar, Dhaka-1207, during November 2006 to February 2007. The materials and methods adopted in the study are discussed in the following sub-headings:

## 3.1 Experimental site

The research work was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental field was located at 90°335´E longitude and 23°774´N latitude at an altitude of 9 meter above the sea level.

## 3.2 Soil

The land was in Agro-ecological Zone of "Madhupur Tract" (AEZ No. 28). The soil of the experimental site was silty clay in texture having pH 5.47-5.63.

## 3.3 Climate

The climate of the experimental site was sub-tropical characterized by heavy rainfall, high humidity, high temperature and relatively long day during the Kharif season (April to September) and heavy rainfall, low temperature and short day period during the Rabi season (October to March). Plenty of sunshine and moderately low temperature prevailed during Rabi season which are suitable for growing of cabbage in Bangladesh.

The detailed record of monthly total rainfalls, temperature, humidity during the period of experiment were noted from the Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1207.

### 3.4 Materials used for the experiment

The variety of cabbage selected for the experiment was LAURELS. $F_1$ hybrid seeds produced by Hungnong Seed Corporation, Republic of Korea were collected from Mollika Seed Company, Siddique Bazar, Dhaka.

### 3.5 Raising of seedling

Cabbage seedlings were raised at the Entomology Field laboratory, Sher-e-Bangla Agricultural University Farm; Dhaka-1207 under special care in three seed beds each of 1m × 1m size. The soil of the seed bed was ploughed, prepared well and the clods were broken into small pieces and converted into loose, friable to obtain good tilth. All weeds, stubbles and dead roots of the previous crops were removed carefully. The seedbeds were dried in the sun to prevent the damping off diseases. Five grams of seeds were sown in seedbeds on 3 October 2006. After sowing, the seedbedss were covered with fine light soil. All seeds were completely germinated within 7 days after sowing. Shading was given by bamboo Chatai over the seedbeds to protect the young seedlings from scorching sunlight and rainfall. Weeding, mulching and irrigation were done from time to time to provide a favourable condition for good growth and raising quality seedling.

### 3.6 Method of cabbage cultivation

#### 3.6.1 Design of the experiment and layout

The study consisting 8 treatments including an untreated control for controlling tobacco caterpillar from seedling to harvesting stages and was laid out in Randomized Complete Block Design (RCBD) with three replications. The entire experimental field was divided into three blocks and each experimental block was divided into eight plots. The distance both blocks and plots was 1 m. The area of each experimental plot was 9 sq. m (3m × 3m).

#### 3.6.2 Land preparation

The experimental land was first opened with a country plough. Ploughed soil was then brought into desirable final tilth by ploughing four times followed by laddering. The stubbles of the crops and uprooted weeds were removed from the field and the land was properly leveled. The field layout was done in accordance to the design, immediately after land preparation. The plots were raised by 10 cm from the soil surface keeping the drain around the plots.

### 3.6.3 Manures, fertilizer and their methods of application

Manures and fertilizers were applied following:

| Manure/Fertilizer | Dose per ha (kg) | Basal dose (Kg/ha) | Top dressing (Kg/ha) | | |
|---|---|---|---|---|---|
| | | | First* | Second** | Third*** |
| Cowdung | 5000 | entire amount | - | - | - |
| Urea | 300 | - | 100 | 100 | 100 |
| TSP | 250 | entire amount | - | - | - |
| MP | 250 | 100 | 50 | 50 | 50 |

*25 days after sowing, ** 45 days after sowing, ***60 days after sowing.

### 3.6.4 Seedling transplanting

To avoid injury to the roots of the seedlings, seedbeds were watered in the morning before up rooting them in the afternoon of the same day. Healthy 25 days old uniform sized seedlings were transplanted in the experimental plots with a spacing of seedling to seedling 50 cm and row to row 60 cm on 29 November, 2006. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. The young transplants were protected from scorching sunlight providing shade with pieces of banana leaf sheath during the day time. At night, they were kept open to allow receiving dew. It was continued up to 5-7 days until they were established in the soil and after that the banana leaf sheaths were removed.


**Plate 1.** Experimental plot of Cabbage at seedling stage
(A) Control plot (B) Ripcord 10EC treated plot

## 3.7 Intercultural Operation

### 3.7.1 Gap filling

At the time of each transplanting few seedlings were transplanted in the border of the experimental plots for gap filling. Very few numbers of the seedling were damaged after transplanting and such seedlings were replaced by healthy seedlings from the same planted earlier on the border of the experimental plot. The seedlings were transplanted with a mass of soil roots to minimize the transplanting shock.

### 3.7.2 Irrigation

After transplanting light irrigation was given to each plot. Supplementary irrigation was applied at an interval of 2-3 days. Stagnant water was effectively drained out at the time of over irrigation. The urea was top dressed in 3 splits as mentioned earlier.

### 3.7.3 Weeding

Weeding was done as and when necessary to break the soil crust and to keep the plots free from weeds. First weeding was done after 20 days of planting and the rest were carried out at an interval of 15 days to keep the plot free from weeds.

### 3.7.4 Earthing up

Earthing up was done in each plot to provide more soil at the base of each plant. It was done 40 and 6o days after transplanting.



**Plate 2.** Experimental plot of cabbage at vegetative stage
(A) Control plot (B) Ripcord 10EC treated plot

### 3.8 Procedure of the study

To investigate the population of this pest the following procedures were followed during studies.

#### 3.8.1 Treatments of the experiment

The comparative effectiveness of the following eight treatments for tobacco caterpillar was evaluated on the basis of reduction of that pest. The individual control measure under each treatment as well as standard practice and control are given below:

$\mathbf{T_1}$ = Neem oil @ 3 ml/l of water

$\mathbf{T_2}$ = Dursban 20EC @ 1ml/l of water

$\mathbf{T_3}$ = Marshal 20EC @ 1ml/l of water

$\mathbf{T_4}$ = Ripcord 10EC @ 1ml/l of water

$\mathbf{T_5}$ = Flubendiamide 24WG @ 0.25g/l of water

$\mathbf{T_6}$ = Lebaycid 50EC @ 1ml/l of water

$\mathbf{T_7}$ = Actara 25WG @ 0.3g/l of water

$\mathbf{T_8}$ = Control (Untreated plot)

#### 3.8.2 Insecticides application

The treatments comprised of one botanical insecticide (neem oil) and six chemical insecticides (Dursban 20EC, Marshal 20EC, Ripcord 10EC, Flubendiamide 24WG, Lebaycid 50EC and Actara 25WG) and untreated control for the management of tobacco caterpillar. Spraying was done at 11.00 am to avoid dews on leaves. First application was done after 14 days of transplanting and was continued at an interval of 7 days. To get complete coverage of plants spraying was done uniformly on the entire plant with special care. All the time the mixture of insecticides in the sprayer was shaken well and sprayed by a Knapsack spray. Before spraying, volume was calibrated to find out the required quantity of spray materials for the same replicated plots. The required quantity was measured as six litres for 7 plots.

### 3.9 Data Collection

Data were collected on number of infested plants, number of infested and healthy leaves per plant, number of bores per leaves and number of larvae per infested plants at 7 days intervals starting from the first initiation of the pest attack to harvesting stage. Caterpillar infested the plant after 13 days of transplanting and continued up to harvesting stage of the crop. Five plants were randomly selected from each plot and tagged. The selected plants were observed regularly at weekly intervals in the morning. Healthy and infested leaves were counted from 5 selected plants in each plot for estimating their infestation intensity. At the head initiation stage to harvesting stage, number of infested head and bores per leaves were counted. After harvesting infested head's total edible part were separated and number of infested and healthy leaves, number of bores per infested leaves and number of larvae per head were counted.


**Plate 3.** Healthy and infested plant of cabbage
(A) Healthy plant (B) Plant infested by *Spodoptera litura* (Fab.)


**Plate 4.** Larvae and pupae of tobacco caterpillar
(A) Fourth instar larvae (B) Pupae

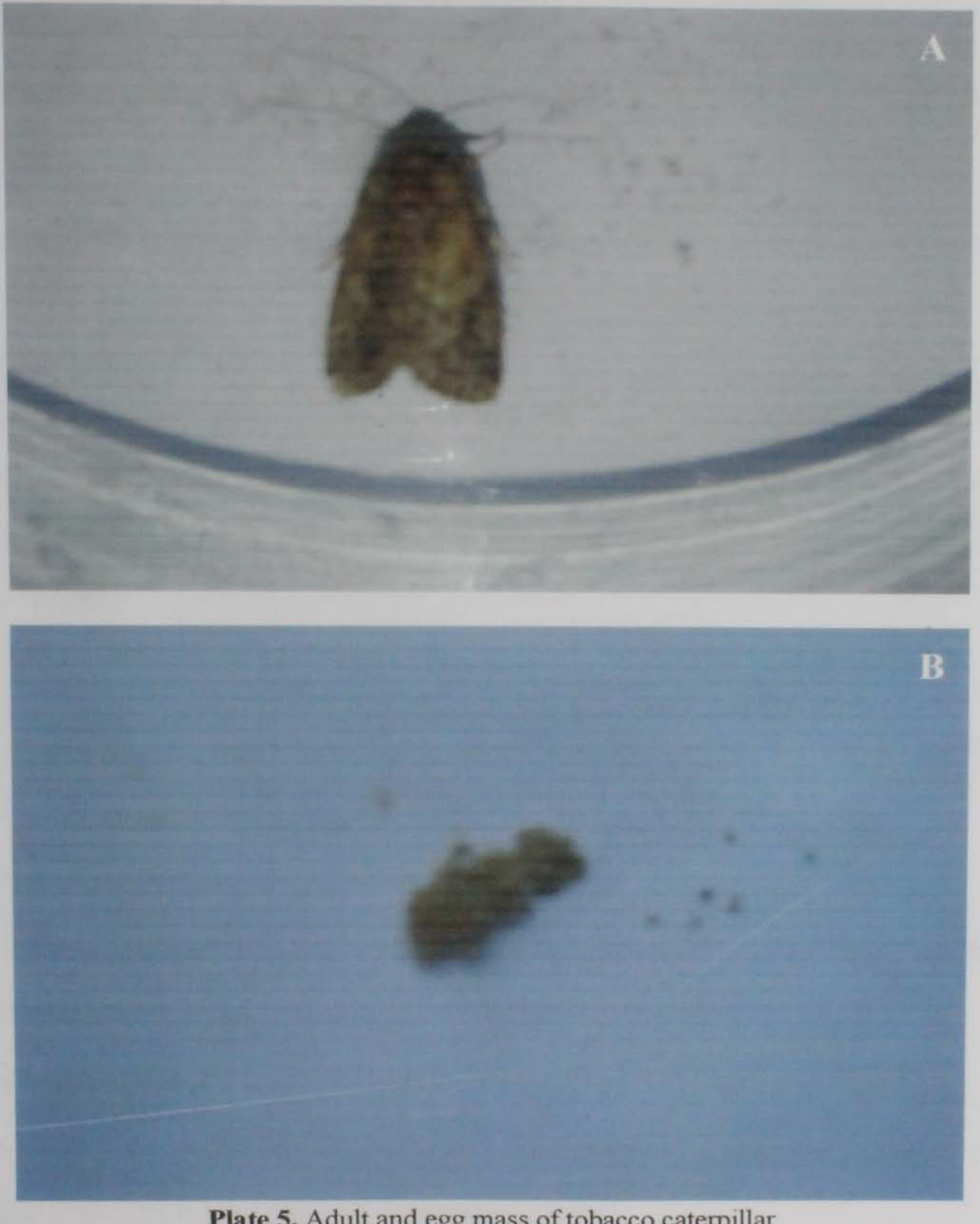


**Plate 5.** Adult and egg mass of tobacco caterpillar
(A) Adult female moth, (B) Egg mass

### 3.9.2 Assessment of treatment effects

**Percent leaf infestation:** The percent leaf infestation by tobacco caterpillar was calculated at early, mid and harvesting stages of head formation using the following formula.

$$\% \text{ Infestation of leaves by number} = \frac{\text{Number of infested leaves}}{\text{Total number of leaves}} \times 100$$

**Percent reduction of leaf infestation:** The effect of different treatments on reducing leaf infestation by tobacco caterpillar was determined by counting the number of bores per leaf at post treatment. The percent reduction of leaf infestation was calculated using the following formula:

$$\% \text{ Reduction} = \frac{\text{Percent leaf infestation in treatment} - \text{percent leaf infestation in control}}{\text{Percent leaf infestation in control}} \times 100$$

**Number of healthy and infested heads:**

Number of healthy (HH) and infested heads (IH) per plot were counted during its growing stage to harvesting stage and infested heads were marked by tagging.

**Weight of healthy and infested heads:**

The weight of healthy and infested heads at harvesting stages of cabbage plants were taken separately per plot for each treatment.

**Infestation percent:** The infested heads were calculated at harvesting stages using the following formulae:

$$\% \text{ Infestation of head by number} = \frac{\text{Number of infested heads}}{\text{Total number of heads}} \times 100$$

$$\% \text{ Infestation of head by Weight} = \frac{\text{Weight of infested heads}}{\text{Total weight of heads}} \times 100$$

**Yield:** After each harvest, the weight of healthy and infested head per plot was recorded in each treatment. The total yield of cabbage per hectare for each treatment was calculated in tons from cumulative head production in a plot. Effect of different treatments on the increase and decrease of cabbage yield over control was calculated in case of tobacco caterpillar.

% increase or decrease of yield over control

$$= \frac{\text{Yield of treated plot- Yield of control plot}}{\text{Yield of the control plot}} \times 100$$

### 3.10 Benefit-Cost analysis:

For benefit cost analysis, records of the costs incurred for labour, insecticide, application of insecticide in each treatment and that of control without insecticide were maintained. The untreated control ($T_8$) did not require any pest management cost. The price of the harvested marketable healthy head of each treatment and that of control were calculated at market rate. The result of Benefit-Cost analysis was expressed in terms of Benefit-Cost Ratio (BCR).

### 3.11 Statistical analysis of data

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package MSTAT-C program. The mean differences among the treatments were separated by Duncan's Multiple Range Test (DMRT).

# Chapter 4
# Results and Discussion

# CHAPTER IV

# RESULTS AND DISCUSSION

The present experiment was conducted to evaluate the effectiveness of neem oil and six insecticides in managing tobacco caterpillar of cabbage in terms of yield contributing characters and yield. The results have been presented and discussed, and possible interpretations have been given under the following headings:

## 4.1 Effectiveness of some insecticides against tobacco caterpillar on leaves of cabbage

### 4.1.1 Early stage of head formation

A remarkable variation was recorded in number of healthy leaves of cabbage at early stage of head formation for neem oil and different insecticides in managing tobacco caterpillar. The highest number of healthy leaves/plant (50.33) was recorded in Ripcord 10EC treated plots, followed by 48.33 and 46.33 in Flubendiamide 24WG and neem oil treated plots, respectively having no significant difference with them (Table 1). In contrast, the lowest number of healthy leaves/plant (35.00) was recorded in untreated control, which was significantly lower than all other insecticides and neem oil treated plots. The same table (Table 1) also revealed that the lowest number of infested leaves/plant (1.00) was recorded in Ripcord 10EC followed by 1.67, 2.0 and 3.0 in Flubendiamide 24WG, neem oil and Dursban 20EC, respectively having no significant difference among them. On the other hand, the highest number of infested leaves/plant (11.00) was recorded in untreated control followed by 8.33, 8.00 in Actara 25WG and Lebaycid 50EC treated plots, respectively with no significant difference between them.

**Table 1.** Effect of neem oil and six selected insecticides on leaf infestation of cabbage by tobacco caterpillar at early stage of head formation

| Treatments | Dose | Number of healthy leaves/plant | Number of infested leaves/plant | Percent leaf infestation | Percent reduction of leaf infestation over control |
|---|---|---|---|---|---|
| Neem oil | 3 ml/l | 46.33 abc | 2.00 d | 4.17 de | 82.58 |
| Dursban 20EC | 1 ml/l | 44.00 bcd | 3.00 d | 6.36 d | 73.43 |
| Marshal 20EC | 1 ml/l | 42.67 cd | 5.33 c | 11.13 c | 53.51 |
| Ripcord 10EC | 1 ml/l | 50.33 a | 1.00 d | 2.01 e | 91.60 |
| Flubendiamide 24WG | 0.25 g/l | 48.33 ab | 1.67 d | 3.32 de | 86.13 |
| Lebaycid 50EC | 1 ml/l | 41.33 d | 8.00 b | 16.19 b | 32.37 |
| Actara 25WG | 0.3 g/l | 40.33 d | 8.33 b | 17.07 b | 28.70 |
| Untreated control | - | 35.00 e | 11.00 a | 23.94 a | - |
| $LSD_{(0.05)}$ | | 4.432 | 1.897 | 3.924 | |

Data are the mean value of 3 replications; each replication is derived from 5 plants per plot. In a column, means having same letter(s) are statistically identical at 5% level of significance.

The lowest percent of leaf infestation (2.01%) was recorded in Ripcord 10EC treated plots followed by 3.32%, 4.17% in Flubendiamide 24WG and neem oil treated plots, respectively having no significant difference among them (Table 1). The highest percent of leaf infestation (23.94%) was recorded in control plot, which was significantly higher than all other insecticides treated plots. The highest percent reduction of leaf infestation over control (91.60%) was observed in Ripcord 10EC treated plots followed by 86.13%, 82.58% in Flubendiamide 24WG and neem oil treated plots, respectively. On the other hand, the lowest percent of leaf infestation reduction over control (28.70%) was recorded in Actara 25WG treated plots.

### 4.1.2 Middle stage of head formation

Number of healthy and infested leaves/plant at middle stage of head formation significantly differed in different treatments. The highest number of healthy leaves/plant (56.33) was recorded in Ripcord 10EC treated plots followed 54.67 in Flubendiamide 24WG and no significant difference was observed between these two treatments (Table 2). On the other hand, the lowest number of healthy leaves (41.33) was recorded in untreated control, which was significantly lower than all other treated plots. Similarly, the lowest number of infested leaves/plant (1.67) was observed in Ripcord 10EC treated plots, followed by 2.67 in Flubendiamide 24WG having no significant difference between them. In contrast, the highest number of infested leaves/plant (11.33) was observed in untreated control, which was significantly higher than all other treated plots.

From the same table (Table 2) it is also observed that the lowest percent of leaf infestation (2.91%) was in Ripcord 10EC treated plots followed by 4.64% in

**Table 2.** Effect of neem oil and six selected insecticides on leaf infestation of cabbage by tobacco caterpillar at middle stage of head formation

| Treatments | Dose | Number of healthy leaves/plant | Number of infested leaves/plant | Percent leaf infestation | Percent reduction of leaf infestation over control |
|---|---|---|---|---|---|
| Neem oil | 3 ml/l | 53.00 bc | 3.67 de | 6.48 ef | 69.90 |
| Dursban 20EC | 1 ml/l | 50.33 bcd | 4.33 d | 7.94 bc | 63.12 |
| Marshal 20EC | 1 ml/l | 49.00 cd | 4.67 d | 8.72 d | 59.50 |
| Ripcord 10EC | 1 ml/l | 56.33 a | 1.67 f | 2.91 g | 86.48 |
| Flubendiamide 24WG | 0.25 g/l | 54.67 ab | 2.67 ef | 4.64 fg | 78.45 |
| Lebaycid 50EC | 1 ml/l | 48.00 d | 8.33 e | 14.72 c | 31.63 |
| Actara 25WG | 0.3 g/l | 46.67 d | 9.67 b | 17.16 b | 20.30 |
| Untreated control | - | 41.33 e | 11.33 a | 21.53 a | - |
| $LSD_{(0.05)}$ | | 4.568 | 1.123 | 1.906 | |

Data are the mean value of 3 replications; each replication is derived from 5 plants per plot. In a column means having same letter(s) are statistically identical at 5% level of significance.

Flubendiamide 24WG treated plots having no significant difference between them. In contrast the highest percent of leaf infestation (21.53%) was recorded in untreated control followed by 17.16% and 14.72% in Actara 25WG and Lebaycid 50EC treated plots, respectively. The percent leaf infestation in untreated control was significantly higher than neem oil and all other insecticides treatments. Similarly, in terms of reduction of leaf infestation over control, the highest percent of leaf infestation reduction over control (86.48%) was recorded in Ripcord 10EC treatment followed by 78.45%, and 69.90% in Flubendiamide 24WG and neem oil treatments, respectively. On the other hand, the lowest percent of leaf infestation reduction over control (20.30%) was recorded in Actara 25WG treatment.

### 4.1.3 Late stage of head formation

Significant variation was recorded in number of healthy leaves of cabbage at late stage of head formation under the different insecticides. The highest number of healthy leaves/plant (62.00) was recorded in Ripcord 10EC treated plots followed by 60.67, 59.33 in treatments Flubendiamide 24WG and neem oil treated plots, respectively (Table 3). On the other hand, the lowest number of healthy leaves/plant (49.00) was recorded in treatment $T_8$ (untreated control), which was statistically identical with that of the $T_7$ (52.33). No significant difference was observed in case of number of healthy leaves/plant in Actara 25WG (52.33), Lebaycid 50EC (54.33), Marshal 20EC (55.00) and Dursban 20EC (56.67). Significantly, the lowest number of infested leaves/plant (1.67) was recorded in Ripcord 10EC treatment, which was statistically identical with Flubendiamide 24WG (2.67) but no significant difference was observed in treatments

**Table 3.** Effect of neem oil and six selected insecticides on leaf infestation of cabbage by tobacco caterpillar at harvesting stage of head formation

| Treatments | Dose | Number of healthy leaves/plant | Number of infested leaves/plant | Percent leaf infestation | Percent reduction of leaf infestation over control |
|---|---|---|---|---|---|
| Neem oil | 3 ml/l | 59.33 abc | 3.33 cd | 5.35 ef | 72.69 |
| Dursban 20EC | 1 ml/l | 56.67 bcd | 4.00 cd | 6.60 de | 66.31 |
| Marshal 20EC | 1 ml/l | 55.00 cd | 4.33 c | 7.31 d | 62.69 |
| Ripcord 10EC | 1 ml/l | 62.00 a | 1.67 e | 2.61 g | 86.68 |
| Flubendiamide 24WG | 0.25 g/l | 60.67 ab | 2.67 de | 4.21 f | 78.51 |
| Lebaycid 50EC | 1 ml/l | 54.33 d | 7.33 b | 11.89 c | 39.31 |
| Actara 25WG | 0.3 g/l | 52.33 de | 8.33 b | 13.73 b | 29.91 |
| Untreated control | - | 49.00 e | 12.00 a | 19.59 a | - |
| $LSD_{(0.05)}$ | | 4.167 | 1.296 | 1.529 | |

Data are the mean value of 3 replications; each replication is derived from 5 plants per plot. In a column means having same letter(s) are statistically identical at 5% level of significance.

Flubendiamide 24WG (2.67), neem oil (3.33) and Dursban 20EC (4.00) (Table 3). In contrast, the highest number of infested leaves/plant (12.00) was recorded in untreated control, which was significantly higher than neem oil and all other insecticides treated plots.

Similarly, the percent leaf infestation of cabbage significantly differed under different treatments at harvesting stage. The lowest percent of leaf infestation (2.61%) was recorded in Ripcord 10EC followed by 4.21% in Flubendiamide 24WG treatment but no significant difference was observed between them. The percent leaf infestation was statistically identical in Flubendiamide 24WG and neem oil. The highest percent of leaf infestation (19.59%) was recorded in untreated control followed by 13.73% in Actara 25WG having significant difference between them. From the same table (Table 3) it is observed that the highest percent of leaf infestation reduction over control (86.68%) was recorded in Ripcord 10EC followed by 78.51% and 72.69% in Flubendiamide 24WG and neem oil, respectively. On the other hand, the lowest percent of leaf infestation reduction over control (29.91%) was recorded in Actara 25WG.

The above results indicate that Ripcord 20EC @ 1 ml/l of water was the most effective insecticides in reducing the tobacco caterpillar infestation on cabbage at early, middle and late stage of head formation. It was able to exceed the standard level of 80% reduction in leaf infestation over control at all stages of head formation. While Flubendiamide 24WG @ 0.25g/l of water and neem oil @ 3 ml/l of water provided satisfactory effectiveness against the tobacco caterpillar on cabbage but they were not able to exceed the standard level of 80% reduction in leaf infestation over control at middle and late stages of head formation although they reduced more than 80% leaf infestation over control at early stage of head formation. Other treatments, such as Dursban 20EC @ 1 ml/l of water, Marshal 20EC @ 1 ml/l of water, Lebaycid 50EC @ 1 ml/l of water, and Actara 25WG @ 0.3 g/l of water provided certain reduction of shoot damage over control but their efficacy was poor. The similar efficacy of Ripcord 10EC against the tobacco caterpillar was reported by Ali and Bakshi (1994) who observed that cypermetherin 10EC @ 1 ml/l of water significantly reduced the percent cabbage plant infestation by *Spdoptera litura* (Fab.). The efficacy of neem oil against the tobacco caterpillar thus found in the present study is more or less similar with the results reported by other researchers against the tobacco caterpillar (Chari *et al*., (1999) and Venkateswarlu, 1992). The efficacy of Flubendiamide 24WG observed in this study is in accordance with the results obtained by Tohnishi *et al*. (2005), who reported that Flubendiamide was the most effective against nine major lepidopterous insect pests including resistant strains. Moreover, Kumar and Krishnaynya (1999) reported that neem oil (1.0%) treatments gave 30.7% reduction of *Spodoptera litura* population after 2 days in the field. Devaki *et al*. (2004) reported that neem oil reduced 66.0-69.0% infestation of *Spodoptera litura* in cabbage. The effectiveness of neem oil and other insecticides found in the present study may vary with that of the other researchers however it is logical because efficacy of insecticides vary with application method, time of application, stage of the crops and also different stages of the insects.

## 4.2 Effectiveness of neem oil and six selected insecticides on infestation of cabbage head by tobacco caterpillar

The effectiveness of neem oil and six selected insecticides against tobacco caterpillar was measured in terms of reduction of head infestation. The highest number of healthy heads per plot (19.67) was recorded in Ripcord 10EC and Flubendiamide 24WG treated plots as against the lowest (16.67) in control plot (Figure 1). No significant difference was observed in number of healthy heads per plot in Ripcord 10EC, Flubendiamide 24WG and neem oil treated plots. Other insecticides, such as Dursban 20EC, Marshal 20EC gave satisfactory production of healthy heads per plot. The number of healthy heads was significantly lower in control plot than all other insecticides treated plots. On the other hand, the lowest number of infested heads per plot (0.33) was observed in Ripcord 10EC and Flubendiamide 24WG treated plots followed by 1.00 in neem oil treated plots having no significant difference among them (Figure 2). Dursban 20EC (1.33) and Marshal 20EC (1.67) had the lower number of infested heads per plot.

Similarly, the lowest percentage of head infestation (1.67) by number was observed in Ripcord 10EC and Flubendiamide 24WG treated plots as against the highest percentage (16.67) in control plot (Table 4). There were significant difference in terms of percent infestation of cabbage head in control and all other treated plots but no significant difference was observed among the Ripcord 10EC, Flubendiamide 24WG and neem oil treated plots in terms of percent infestation of cabbage head. In terms of percent reduction of head infestation over control, the highest efficacy (89.98%) was recorded in Ripcord 10EC and Flubendiamide 24WG treated plots followed by 70.01% in neem

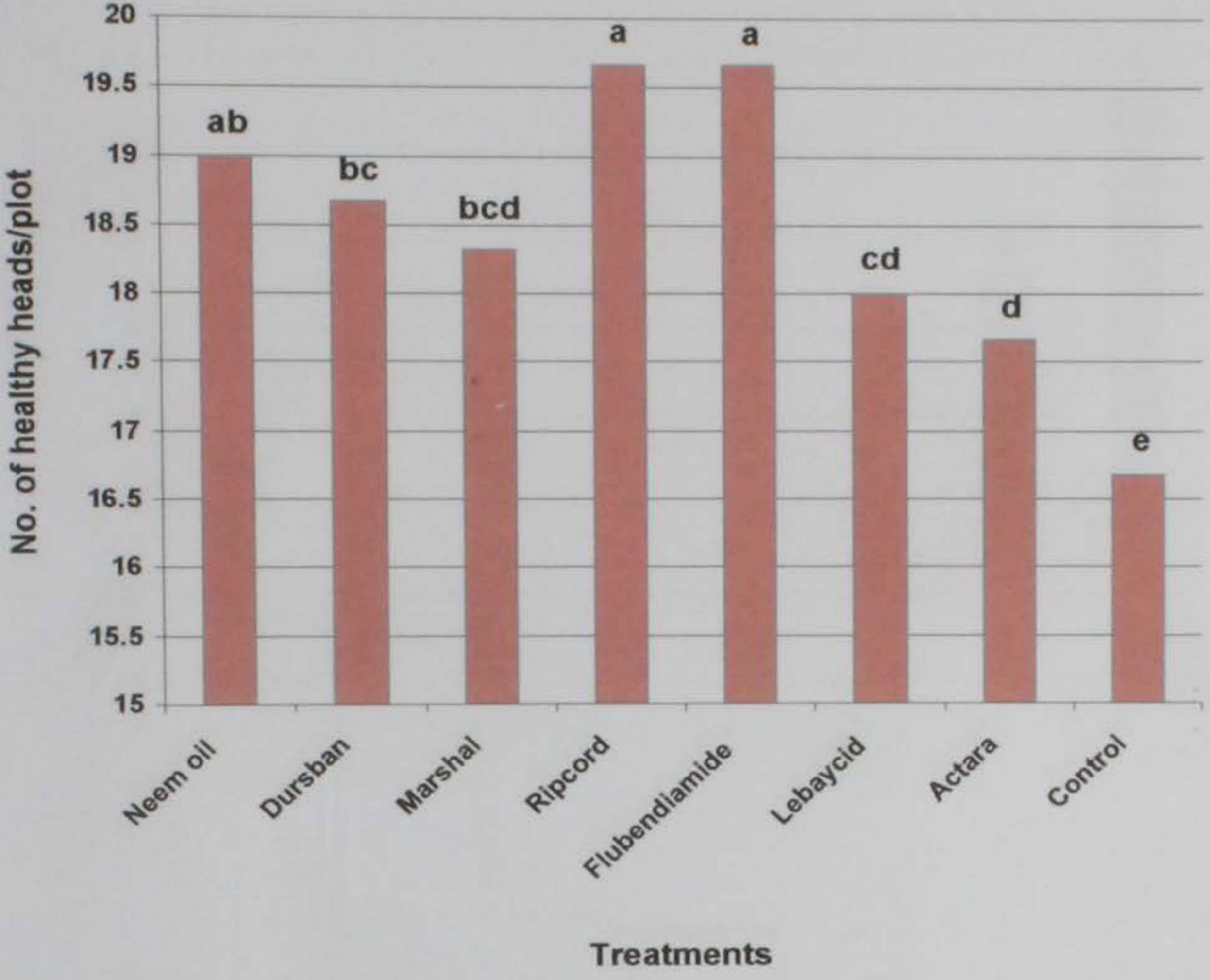


**Figure 1.** Number of healthy head of cabbage per plot in different treatments. Bars having same letter are statistically identical at 5% level of significance.

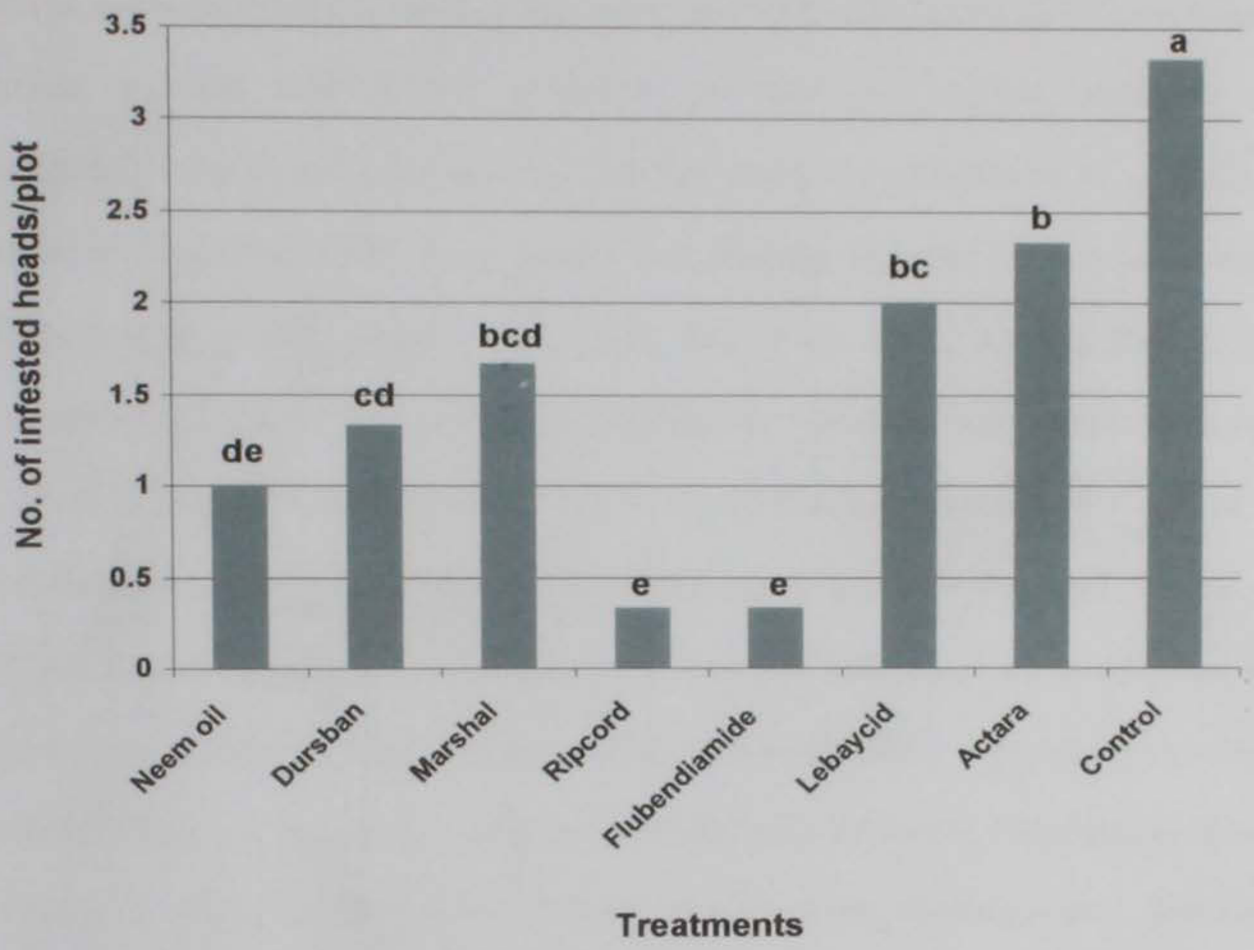


**Figure. 2.** Number of tobacco caterpillar infested head of cabbage per plot in different treatments. Bars having same letter are statistically identical at 5% level of significance.

oil treated plots. Ripcord 10EC and Flubendiamide 24WG were able to exceed the standard level (80%) loss protection over control. But neem oil and other insecticides such as Dursban 20EC, Marshal 20EC, Lebaycid 50EC and Actara 25WG were failed to provide standard level (80%) protection of loss over control. However, these insecticides significantly reduced the tobacco caterpillar infestation in cabbage. The results of the present study were similar with findings reported by several researchers (Tohnisi *et al*., 2005; Devaki *et al*., 2004; Rao *et al*., 1993, Ali and Bakshi, 1994). Tohnishi *et al*. (2005) reported that Flubendiamide was an effective insecticide against *S. litura*. Moreover, Ali and Bakshi (1994) found that cypermethrin at 1 ml/l of water was the most effective insecticides in controlling *S. litura* in the field. Devaki *et al*. (2004) reported that neem oil reduced 66.0-69.0% infestation of *Spodoptera litura*, which was similar of the present findings. Although many researchers reported the similar efficacy of neem oil against tobacco caterpillar however, Babu and Krishnaynya (1998) reported less effectiveness of neem oil against this obnoxious pest. The findings of the present study might be differed with that of other researchers however it is logical because the effectiveness of insecticides may vary with different larval instars of the pest. Singh *et al*. (1998) reported that 2nd instar larvae of *Spodoptera litura* were more susceptible to cypermethrin 3rd instar larvae.

**Table 4.** Effectiveness of neem oil and some selected insecticides in reducing tobacco caterpillar infestation on cabbage head

| Treatments | Dose | Infestation (%) | Percent reduction of infestation over control |
|---|---|---|---|
| Neem oil | 3 ml/l | 5.00 de | 70.01 |
| Dursban 20EC | 1 ml/l | 6.67 cd | 59.99 |
| Marshal 20EC | 1 ml/l | 8.33 bcd | 50.03 |
| Ripcord 10EC | 1 ml/l | 1.67 e | 89.98 |
| Flubendiamide 24WG | 0.25 g/l | 1.67 e | 89.98 |
| Lebaycid 50EC | 1 ml/l | 10.00 bc | 40.01 |
| Actara 25WG | 0.3 g/l | 11.67 b | 29.99 |
| Untreated control | | 16.67 a | - |
| $LSD_{(0.05)}$ | | 4.481 | |

Data are the mean value of 3 replications. In a column means having same letter(s) are statistically identical at 5% level of significance.

## 4.3 Effectiveness of neem oil and six selected insecticides on yield of cabbage

Cabbage head yield significantly varied in neem oil than selected insecticides treated plots under the present trail. The highest healthy yield (70.34 t/ha) was recorded in Ripcord 10EC treated plot because of lower infestation, which was statistically identical with Flubendiamide 24WG treated plot (69.35 t/ha) but significantly differed from other insecticides and control plot (Table 5). Neem oil (64.52 t/ha), Marshal 20EC (60.58 t/ha), Lebaycid 50EC (59.13 t/ha) and Actara 25WG produced significantly higher healthy yield of cabbage than control but no significant difference was observed for healthy yield in neem oil (64.52t/ha) and Dursban 20EC (63.63) treated plots. Similarly, the lowest healthy yield (49.36 t/ha) was recorded in untreated control, which was significantly lower than any other treated plots. In contrast, the highest infested head yield (5.25 t/ha) was recorded in untreated control, which was statistically identical with that of Actara 25WG (4.06 t/ha) and Lebaycid 50EC (3.56 t/ha) treated plots. The Table 5 also reveals that the total head yield was higher (71.12 t/ha) in Ripcord 10EC treated plots followed by 70.11 t/ha in Flubendiamide 24WG treated plots having no significant difference with them. On the other the lowest total head yield (54.61 t/ha) was recorded in untreated control, which was significantly lower than all other insecticides treated plots.

In terms of percent infestation of head by weight, neem oil and six selected insecticides showed varied effectiveness against the tobacco caterpillar. Significantly, the lowest percent infestation (1.02%) was recorded in Ripcord 10EC treated plots followed by 1.10% and 3.11% in Flubendiamide 24WG and neem oil treated plots, respectively

**Table 5.** Effectiveness of neem oil and six selected insecticides in managing tobacco caterpillar on head weight of cabbage yield and percent infestation

| Treatments | Dose | Head yield (t/ha) | | | Infestation (%) |
|---|---|---|---|---|---|
| | | Healthy | Infested | Total | |
| Neem oil | 3 ml/l | 64.52 b | 2.07 cd | 66.59 bc | 3.11 cd |
| Dursban 20EC | 1 ml/l | 63.63 bc | 2.59 bcd | 66.21 bc | 3.86 c |
| Marshal 20EC | 1 ml/l | 60.58 cd | 3.20 bc | 63.78 cd | 5.09 bc |
| Ripcord 10EC | 1 ml/l | 70.34 a | 0.78 d | 71.12 a | 1.02 d |
| Flubendiamide 24WG | 0.25 g/l | 69.35 a | 0.76 d | 70.11 ab | 1.10 d |
| Lebaycid 50EC | 1 ml/l | 59.13 d | 3.56 abc | 62.69 cd | 5.68 bc |
| Actara 25WG | 0.3 g/l | 57.01 d | 4.06 ab | 61.07 d | 6.66 b |
| Untreated control | | 49.36 e | 5.25 a | 54.61 e | 9.57 a |
| LSD$_{(0.05)}$ | | 3.715 | 1.729 | 4.062 | 2.482 |

Data are the mean value of 3 replications. In a column means having same letter(s) are statistically identical at 5% level of significance.

having no significant difference among them (Table 5). The highest percent of head infestation of cabbage (9.57%) was recorded in untreated control, which was significantly higher than all other treated plots. Percent head infestation by weight did not significantly differ in neem oil (3.11), Dursban 20EC (3.86), Marshal 20EC (5.09 and Lebaycid 50EC (5.68). The same way, Figure 3 revealed that Ripcord 10EC reduced the highest percent of yield loss (89.34%) of cabbage over control followed by 88.51% in Flubendiamide 24WG. Neem oil also reduced significant percent of yield loss of cabbage. Only Ripcord 10 EC and Flubendiamide 24WG were able to exceed the standard level (80%) for protection loss over control. Although, the other insecticides reduced the damage of tobacco caterpillar however their effectiveness were below the standard level (80%). The effectiveness of Ripcord 10EC and Flubendiamide thus obtained in the present finding validates the results reported by Ali and Bakshi (1994) and Tohnishi *et al*. (2005). Ali and Bakshi (1994) reported that cypermethrin 10 EC at 1 ml/litre of water significantly reduced the percentage of plant infestation by tobacco caterpillar and increased yield of cabbage while, Tohnishi *et al*. (2005) observed higher efficacy of Flubendiamide against the tobacco caterpillar. Moreover, the similar effectiveness of neem oil and chlorpyriphos was also reported by Chari *et al*. (1999), who observed that neem oil at 1.5% concentration was highly effective against *Spodoptera litura* in the nursery and chlorpyriphos was the best after neem oil treatment. Venkateswarlu *et al*. (1992) stated that neem oil at 1% in combination with endosulfan 35 EC at 0.07% was the most effective in reducing infestation of *S. litura, Maruca testualis* ann *Helicoverpa armigera* and increasing black gram yield.

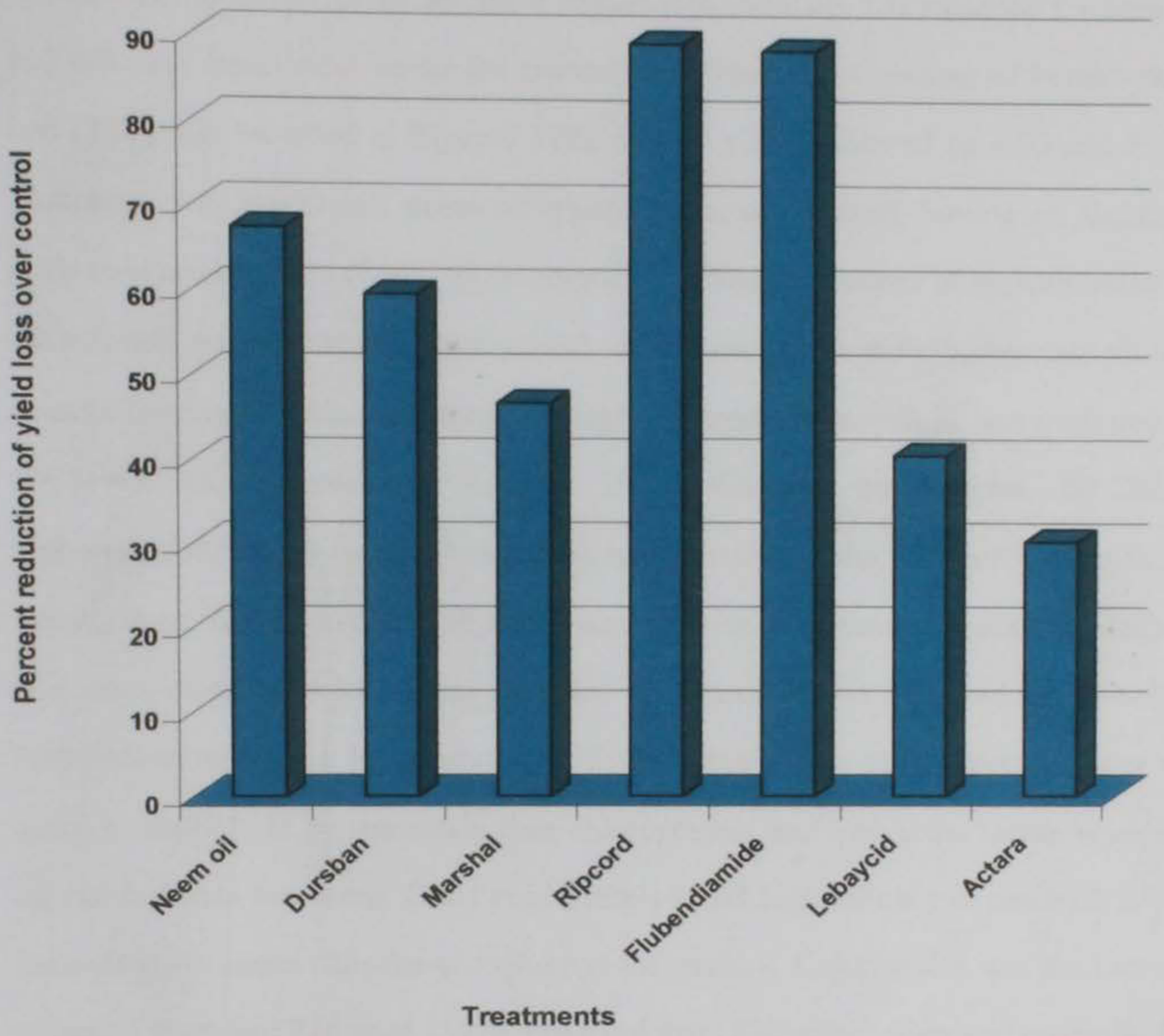


**Figure 3.** Effect of neem oil and six selected insecticides on reduction of yield loss of cabbage.

## 4.4 Effectiveness of neem oil and six selected insecticides on number of bores per infested leaf caused by tobacco caterpillar

In terms of number of bores per leaf a remarkable variation was recorded for neem oil and different insecticides under the present trail. The lowest number of bores/infested leaf (3.33) was recorded in Ripcord 10EC treated plots, followed by 4.00 and 5.67 in Flubendiamide 24WG and neem oil treated plots, respectively having no significant difference among them (Table 6). In contrast, the highest number of bores/infested leaf (28.67) was recorded in untreated control which was significantly higher than all other insecticides treated plots. Similarly, the highest percent reduction of bores/infested leaf (88.39%) was recorded in Ripcord 10EC followed by 86.05%, 80.22% in Flubendiamide 24WG neem oil treated plots, respectively with no significant difference among them. On the other hand, the lowest percent reduction of bores bores/infested leaf over control (39.55%) was recorded in Actara 25WG followed by 41.86% in Lebaycid treated plots. Singh *et al.* (1998) 3rd instar larvae of *Spodoptera litura* were more susceptible to cypermethrin than chlorpyriphos and 2nd instar larvae were more susceptible than 3rd instar. Chari *et al.* (1999) found high efficacy of neem oil at 1.5% concentration against *Spodoptera litura* in the nursery. Chlorpyrifos was the best after neem oil treatment Rao *et al.* (1996) observed that $LC_{50}$ values increased gradually from the first to fourth instar larvae and cypermethrin was relatively more toxic than fenvelerate against different larval instars of *S. litura.* Moreover, adult emergence, growth, survival, larval and pupal weight, number of eggs laid and hatchability of eggs decreased with increase in concentration of neem oil (Rao *et al.*, 1993). Therefore the findings obtained in the present study validate the results of the other researchers.

**Table 6.** Number of bores per infested leaf of cabbage at harvesting time in different treatments

| Treatments | Dose | Number of bores/leaf | Percent reduction over control |
|---|---|---|---|
| Neem oil | 3 ml/l | 5.67 e | 80.22 |
| Dursban 20EC | 1 ml/l | 9.00 d | 68.61 |
| Marshal 20EC | 1 ml/l | 13.67 c | 52.32 |
| Ripcord 10EC | 1 ml/l | 3.33 e | 88.39 |
| Flubendiamide 24WG | 0.25 g/l | 4.00 e | 86.05 |
| Lebaycid 50EC | 1 ml/l | 16.67 b | 41.86 |
| Actara 25WG | 0.3 g/l | 17.33 b | 39.55 |
| Untreated control | | 28.67 a | - |
| $LSD_{(0.05)}$ | | 2.901 | |

Data are the mean value of 3 replications. In a column means having same letter(s) are statistically identical at 5% level of significance.

## 4.5 Effect of neem oil and six selected insecticides on number of larvae per infested head

In terms of number of larvae per infested head, a significant variation was observed for neem oil and different insecticides tested against the tobacco caterpillar under the present trail. The lowest number of larvae/infested head (0.33) was recorded in Ripcord 10EC and Flubendiamide 24WG treated plots followed by 1.0 in neem oil treated plots having no significant difference among them (Table 7). In contrast, the highest number of larvae/infested head (4.33) was recorded in untreated control followed by 2.33 and 2.00 in Actara 25WG and Lebaycid 50EC treated plots, respectively. The number of larvae per infested head significantly higher in control plots than neem oil and all other insecticides treated plots. Similarly the highest percent of reduction of larvae/head over control (92.38%) was recorded in Ripcord 10EC and Flubendiamide 24WG. On the other hand, the lowest percent of reduction of larvae/head over control (46.19%) was recorded in Actara 25WG. Neem oil reduced 76.91% larval population per infested head over control. The finding of the present study was in accordance with that of other researchers. Rao *et al.* (1994) observed that cypermethrin was relatively more toxic than fenvelerate against different larval instars of *S. litura*. Peter *et al.* (1987) noticed that chlorpyrifos gave 100 percent mortality of the first instar larvae of *Spodoptera litura*, when exposed to the treated leaves one hour after dusting. Moreover, adult emergence, growth, survival, larval and pupal weight decreased with increase in concentration and neem oil had the greatest effects, followed by neemark, biosol and repelin (Rao *et al.*, 1993). Singh *et al.* (1998) 3rd instar larvae of *Spodoptera litura* were more susceptible to cypermethrin than chlorpyriphos Rao *et al.*, (1996) observed that $LC_{50}$ values increased gradually from the first to fourth instar and cypermethrin was relatively more toxic than fenvelerate against different larval instars of *S. litura*.

**Table 7.** Number of tobacco caterpillar per infested head at harvesting time in different treatments

| Treatments | Dose | Number of larvae/head | Percent reduction over control |
|---|---|---|---|
| Neem oil | 3 ml/l | 1.00 de | 76.91 |
| Dursban 20EC | 1 ml/l | 1.33 cd | 69.28 |
| Marshal 20EC | 1 ml/l | 1.67 bcd | 61.43 |
| Ripcord 10EC | 1 ml/l | 0.33 e | 92.38 |
| Flubendiamide 24WG | 0.25 g/l | 0.33 e | 92.38 |
| Lebaycid 50EC | 1 ml/l | 2.00 bc | 53.81 |
| Actara 25WG | 0.3 gm/l | 2.33 b | 46.19 |
| Untreated control | | 4.33 a | - |
| $LSD_{(0.05)}$ | | 0.896 | - |

Data are the mean value of 3 replications. In a column means having same letter(s) are statistically identical at 5% level of significance.

### 4.7 Relationship between percent leaf infestation in number and cabbage yield

The data on percent leaf infestation were regressed against yield/ha. A linear relationship was found between them and they were positively correlated. It was evident from the Figure 7 that the equation $y = -0.7676x + 72.186$ gave a good fit to the data, and the co-efficient of determination ($R^2$=0.9442) showed that, fitted regression line had a significant regression co-efficient. It is evident from the regression line and equation that, the yield increased with the decreased of percent leaf infestation for neem oil and different insecticides in managing tobacco caterpillar in cabbage.

Correlation study was done to establish a relationship between percent head infestation and yield (t/ha) of cabbage. The figure 8 revealed the significant positive correlations between these two characters. The regression equation $y = -1.8276x + 72.767$ gave a good fit to the data and the value of the co-efficient of determination was $R^2 = 0.9907$, which indicated very strong correlations. From this it can be concluded that percent head infestation decreased the yield.

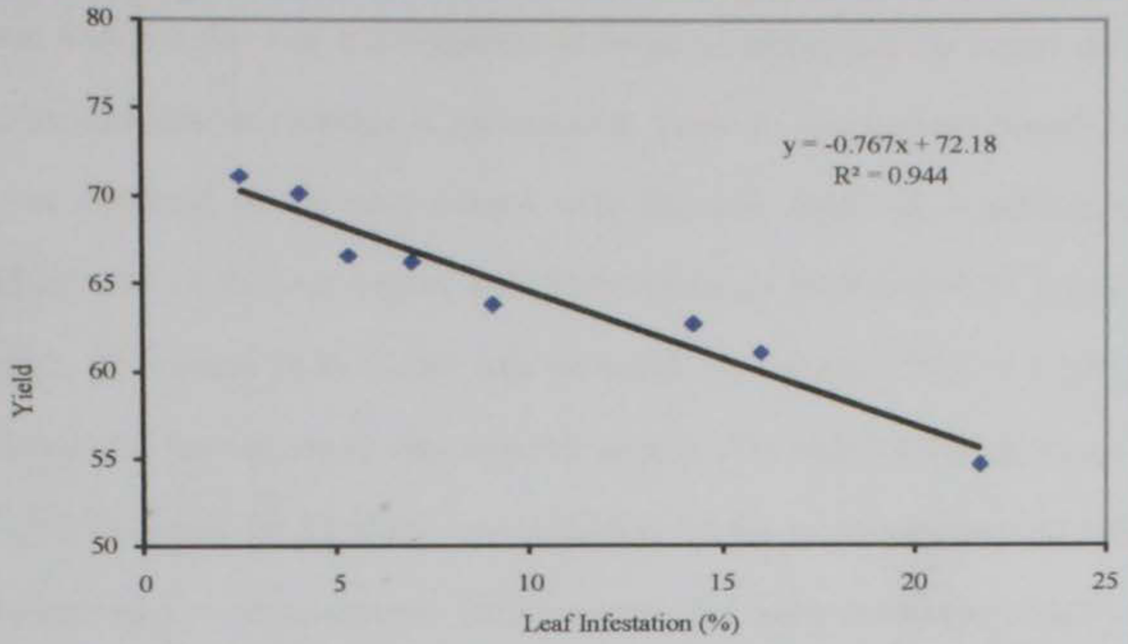


Figure 4. Relationship between leaf infestation and cabbage yield

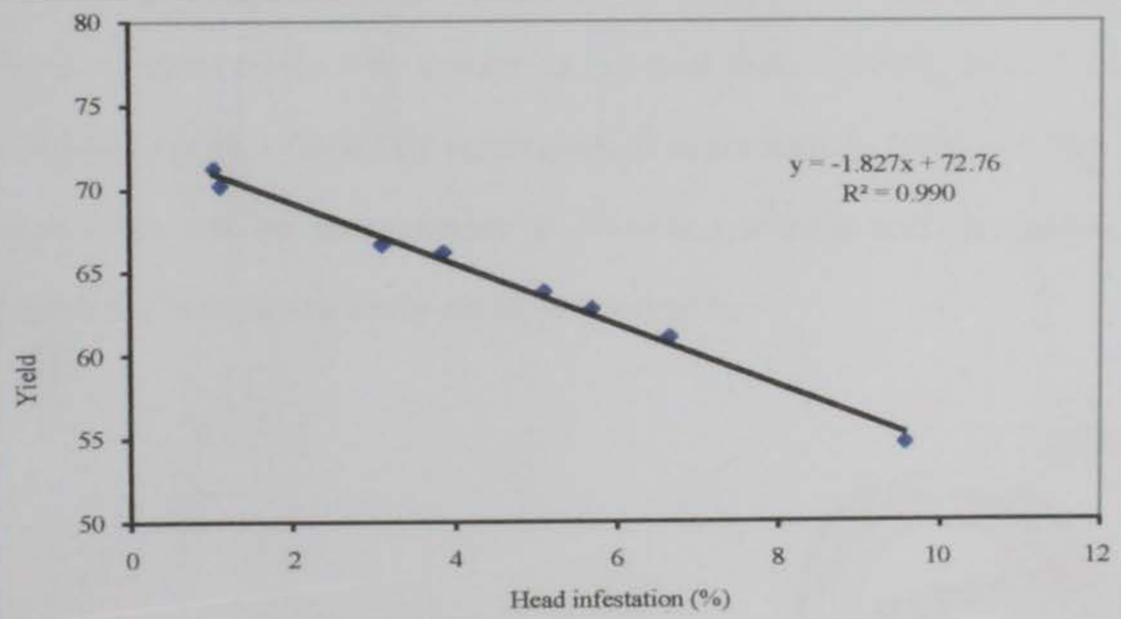


Figure 5. Relationship between head infestation and cabbage yield

## 4.9 Benefit Cost Analysis

Economic analysis for the management of tobacco caterpillar by neem oil and six selected insecticides on cabbage is presented in Table 8. The highest benefit cost ratio (1.55) was obtained in the plot treated with Ripcord 10EC @ 1 ml/litre of water followed by 1.49 in the plot treated with Flubendiamide 24WG @ 0.25 g/litre. On the other hand, the lowest BCR (1.09) was recorded for Actara 25WG 0.3 @ g/litre of water. Similarly, the net return was also the highest (Tk. 633,700/ha) in Ripcord 10EC treated plot followed by 625900/- and 595350/- Tk/ha in Flubendiamide 24WG and neem oil treated plots, respectively. Other insecticides, such as Dursban 20EC, Marshal 20EC, Lebaycid 50EC and Actara 25 WG also gave the positive benefit cost ratio (BCR) for the management of tobacco caterpillar of cabbage. The result in terms of benefit cost ratio (BCR) for the management of tobacco caterpillar of cabbage thus found in the present study was similar to Ali and Baksi (1994), who observed the highest benefit cost ratio (BCR) by application of cypermethrin 10EC at 1 ml/l of water as calendar spray for the management of *Plutella xylostella* and *Spodoptera litura*. Thus, the result found in this study validates his reports.

**Table 8.** Economic analysis of neem oil and six selected insecticides in managing tobacco caterpillar of cabbage

| Treatments | Cost of pest Management (Tk.) | Yield (t/ha) | | Gross return (Tk.) | Net Return (Tk.) | Adjusted net return (Tk.) | Benefit cost ratio |
|---|---|---|---|---|---|---|---|
| | | Healthy | Infested | | | | |
| Neem oil | 60,200 | 64.52 | 2.07 | 655,550 | 595,350 | 75500 | 1.25 |
| Dursban 20EC | 58,400 | 63.63 | 2.59 | 649,250 | 590,850 | 71000 | 1.22 |
| Marshal 20EC | 45,200 | 60.58 | 3.20 | 621,800 | 576,600 | 56750 | 1.26 |
| Ripcord 10EC | 73,600 | 70.34 | 0.78 | 707,300 | 633,700 | 113850 | 1.55 |
| Flubendiamide 24WG | 71,400 | 69.35 | 0.76 | 697,300 | 625,900 | 106050 | 1.49 |
| Lebaycid 50EC | 41,400 | 59.13 | 3.56 | 609,100 | 567,700 | 47850 | 1.16 |
| Actara 25WG | 33,800 | 57.01 | 4.06 | 590,400 | 556,600 | 36750 | 1.09 |
| Untreated control | 0 | 49.36 | 5.25 | 519,850 | 519,850 | | - |

**Cost of insecticides:** Neem oil @ 150 Tk./liter, Dursban 20EC @ Tk. 50/100 ml bottle, Marshal 20EC @ Tk. 40/50 ml bottle, Ripcord 10EC @ Tk. 115/100 ml bottle, Flubendiamide 24WG @ Tk 5000.00/kg, Lebaycid 50EC @ Tk.140/100 ml bottle, Actara 25EC @ Tk. 35/5g packet.

**Labour cost:** Two labourers/spray/ha @ Tk 110.00/day. Spray volume required: 500 l/ha (Anon. 1994).

**Average market price of cabbage:** Tk. 7/Kg. Value of only the healthy heads has been considered in calculating the BCR.

# Chapter 5

# Summary and Conclusion

# CHAPTER V

# SUMMARY AND CONCLUSION

The present study was carried out at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from November 2005 to February, 2006 to evaluate the comparative effectiveness of neem oil and six insecticides against the tobacco caterpillar on cabbage. The study comprised eight treatments, such as neem oil, Dursban 20EC, Marshal 20EC, Ripcord 10EC, Flubendiamide 24WG, Lebaycid 50EC, Actara 25WG and untreated control. Ripcord 10EC @ 1 ml/l of water applied at seven days interval reduced 91.60, 86.48 and 86.68% infestation of leaf over control at early, middle and harvesting stage of head formation, respectively. Flubendiamide 24WG @ 0.25g/l of water and neem oil @ 3 ml/l of water provided good protection of cabbage leaf infestation against the tobacco caterpillar at three different stages of head formation.

Neem oil and six selected insecticides significantly reduced the cabbage head infestation by number compared to control. Ripcord 10EC and Flubendiamide 24WG produced the highest number (19.67) of healthy heads/plot as against the lowest number of infested heads/plot (0.33). Only 1.67% head infestation was obtained in these treatments while in control that was 16.67%. These two insecticides provided 89.98% reduction of tobacco caterpillar infestation over control. Neem oil also provided 70.01% reduction of tobacco caterpillar infestation of cabbage head by number over control.

Yield of cabbage significantly varied in neem oil and other insecticides treated plots. Both healthy and total yield were the highest in Ripcord 10EC (70.34 t/ha and 71.12 t/ha, respectively) treated plots. Similar healthy and infested yields were obtained (69.35 t/ha and 70.11t/ha, respectively) in Flubendiamide 24WG treated plots. Infested yield (5.25 t/ha) and percent of infestation by weight (9.57%) were the highest in untreated control. Both Ripcord 10EC and Flubendiamide 24WG provided more than 80% reduction of yield loss over control. Neem oil reduced 67.50% yield loss over control. Although, the other insecticides reduced the yield loss of cabbage over control but their efficacy was not satisfactory.

Ripcord 10EC and Flubendiamide 24WG significantly reduced the number of bores per infested leaf caused by tobacco caterpillar and the number of tobacco caterpillar larvae per infested leaves. Ripcord 10EC reduced 88.39% bores per infested leaves while Flubendiamide reduced 86.05% bores per infested leaf. In terms of reduction of number of larvae per infested head both these insecticides reduced 92.38% larval population per infested head.

There were highly negative correlations between percent leaf infestation and percent head infestation with yield of cabbage. There was inconsistency among the neem oil and different insecticides in their effects on head infestation as well as on the yield of cabbage. However, the highest BCR (1.55) was obtained by the application of Ripcord 10EC @ 1 ml/l of water at weekly intervals. Almost similar BCR (1.49) was obtained by application of Flubendiamide 24WG @ 0.25 g/l of water applied at same interval.

Actara 25WG @ 0.3 g/l of water provided the lowest protection, minimum yield and the lowest BCR (1.09).

Based on the above results it can be concluded that Ripcord 10EC @ 1 ml/l of water and Flubendiamide 24WG @ 0.25g/l of water may be recommended for the management of tobacco caterpillar, *Spodoptera litura* (Fab.) in cabbage but it is necessary to fix up the appropriate dose of these two insecticides against the tobacco caterpillar and also requires further trial in large scale in farmer's field.

# Chapter 6

# References

# CHAPTER VI

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