STUDIES ON THE EFFECT OF VARIATION IN SOWING DATES ON THE INCIDENCE OF CHICKPEA INFESTATION BY POD BORER *HELICOVERPA ARMIGERA* (HUBNER) ITS BIOLOGY AND NEEM BASED BOTANICALS MANAGEMENT IN LABORATORY

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CERTIFICATE

This is to certify that the thesis entitled "**STUDIES ON THE EFFECT OF VARIATION IN SOWING DATES ON THE INCIDENCE OF CHICKPEA INFESTATION BY POD BORER *HELICOVERPA ARMIGERA* (HUBNER) ITS BIOLOGY AND NEEM BASED BOTANICALS MANAGEMENT IN LABORATORY**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **SASTHI PADA RAY** bearing **Roll No.1015**, **Registration No. 01015** 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 acknowledged.

Dated:

Place: Dhaka, Bangladesh

(Dr. Md. Mizanur Rahman)

Research Supervisor


DEDICATED
TO
MY BELOVED PARENTS

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By

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ABSTRACT

The present study was conducted to evaluate the effects of variation in sowing dates on chickpea, its biology and influence of neem based botanicals for the management of the pest under laboratory condition in experimental field of Sher-e-Bangla Agricultural University, Dhaka during Rabi 2007-2008. The sowing date was considered as treatment to find out the incidence and damage severity of pod borer in chickpea during the growing season. They were T_1: Sowing on 10th November' 07; T_2: Sowing on 20th November' 07; T_3: Sowing on 30th November' 07; T_4: Sowing on 10th December' 07' T_5: Sowing on 20th December' 07; T_6: Sowing on 30th December' 07. On the other hand application of Neem based botanicals were considered as treatments of the experiment which were: T_1: Spraying with neem oil @ 0.5% + trix 5gm; T_2: Spraying with neem oil @ 1.0% + trix 5gm; T_3: Spraying with neem oil @ 1.5% + trix 5gm; T_4: Sprayirg with neem seed kernel extract @ 0.5% + trix 5gm; T_5: Sprayirg with neem seed kernel extract @ 1.0% + trix 5gm; T_6: Sprayirg with neem seed kernel extract @ 1.5% + trix 5gm; T_7: Spraying with neem leaf extract @ 50ml + trix 5gm and T_8: Untreated control. The average length and breadth of the eggs was 0.45 ± 0.003 mm and of 0.48 ± 0.004 mm with the average incubation period of 3.50 ± 0.15 days. The *Helicoverpa armigera* (Hubner) larva has six instars. The average length and breadth of pre-pupal stage was 20.40 ± 0.42 mm and 4.37 ± 0.18 mm with average pre-pupal period of 1.89 ± 0.12 days. In case of male pupa the average length and breadth was of 15.7 ± 0.28 mm and 2.51 ± 0.08 mm. again, in female it was 16.8 ± 0.26 mm and 3.31 ± 0.11 mm. At early fruiting stage, the highest percent of pod infestation per plant (43.14%) was found in the treatment T_6 and the lowest (17.53 in the treatment T_1. At mid fruiting stage, the highest percent of pod infestation (52.35%) per plant was found in the treatment T_6 and the lowest (25.61%) was found in the treatment T_1. At late fruiting stage, the highest percent of pod infestation (58.52%) per plant was found in the treatment T_6 and the lowest (30.59%) in the treatment T_1. In terms of yield, the highest yield (1538 kg/ha) was recorded in the treatment T_2 and the lowest (750 kg/ha) was recorded from the treatment T_6. The highest pre-weight (3.35 mg) of full fed larva was recorded in the treatment T_8, and the lowest (3.03 mg) of in the treatment T_3. The highest total life span (32.23±0.31) was recorded in the treatment T_8, while the lowest (21.28±0.23) from T_3. In case of the larval cumulative mortality for chickpea pod borer larva treated with different neem based botanicals the highest percentage (20.33%) of morality was recorded from the treatment component T_3, whereas the lowest (3.00%) was recorded in T_8. Considering the antifeedant effect of different botanicals on chickpea pod borer larva in case of larval cumulative mortality the highest percentage (11.67%) of morality was recorded in the treatment T_3, whereas the lowest (2.00%) was recorded in T_8.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Chapter – I

Introduction

CHAPTER I

INTRODUCTION

Chickpea, *Cicer arietinum* L. is one of the important pulse crops in the world. It has been cultivated for centuries in India, Pakistan and Bangladesh. The crop is variously known as chola, boot or botjam in different parts of Bangladesh. It is generally grown under rain-fed or residual soil moisture conditions in rabi season. Among the major pulses grown in Bangladesh, chickpea ranked fifth in area and production but second in consumption priority. It covers an area of 16,446 ha producing 11,980 tons of yield with national average of 748 kg/ha (BBS, 2004).

The grain of chickpea is a cheap and rich source of protein (21.1%), its dry stems and husks serve as good source of animal feeds (Kay, I979). Taking chickpea in "Ifter" during *Ramadan* is a common Islamic culture in Bangladesh. As well as being an important source of human food and animal feed, it also helps in the management of soil fertility through symbiotic nitrogen fixation from the atmosphere, particularly in dry lands (Sharma and Jodha, 1984; Suzuki and Konno, 1982).

Yield of chickpea in Bangladesh is miserably low (728 kg/ha) as compared to that of other countries like India (833 kg/ha), Myanmar (1106 kg/ha), Mexico (1600 kg/ha), Esrael (1813 kg/ha), Russian Federation (2400 kg/ha), Kazakjhastan (3000 kg/ha) and China (6000 kg/ha) (FAO, 2006). There are many factors responsible for low yield of chickpea. Among them, insect pests appear to be the

most vital factor. In Bangladesh, chickpea is attacked by eleven species of insect pests (Rahman *et al.*, 1982). Among these pests the pod borer, *Helicoverpa armigera* (Hubner) is one of the most serious pest of the chickpea growing areas of the country (Begum *et al.*, 1992). The young larvae of this pest feed on the foliage for some time and later bore into the pod. In a country wide survey, averages of 30 to 40 percent pods were found to be damaged by pod borer and it was estimated as 400 kg/ha yields losses. In favourable condition, the pod damage goes to 90-95% (Shongal and Ujagir, 1990; Sachan and Katti, 1994).

Farmers are being reluctant to cultivate chickpea due to its susceptibility to pod borer. The young larva skeletonizes the leaves, while grown up larva bores the pods and feeds on the seeds, thereby rendering them unfit for human consumption.

At present, effective control techniques other than insecticide application against the pest are not available. The poor farmers of Bangladesh cannot always afford to use insecticides. Again, indiscriminate use of insecticides for the management of insect pests has resulted in the development of resistance to insecticides, pest resurgence and appearance of secondary pests (Shengal and Ujagir, 1990; Butter *et al.*, 1992). Moreover, continuous use of insecticides leads to the hazardous effects on the pollinators natural enemies like predators and parasitoids, etc. and also causes the environmental pollution (Nagrare and More, 1998). Under these circumstances, it becomes necessary to find out some eco-friendly alternative methods for pod borer management. Out of which the manipulation of the cultural practices like changing the dates of sowing and using botanicals such as - Neem oil, Neem seed kernel, Neem leaf

extract can be eco-friendly components in formulating the integrated pest management approach.

To find out the effective method for controlling a particular pest, it is absolutely necessary to know the biology and ecology of the pest, its habit and habitats, its food and feeding pattern *etc.* so to determine the most vulnerable stage in its life cycle at which the particular insect can be killed very easily. In Bangladesh sufficient information on chickpea pod borer for its proper management is not available so far and no in-depth studies have been made. The chemical insecticides still remain the key tools for the management of the pest.

Under the above perspective, changing the date of sowing and application of botanicals thought to be eco-friendly components for the management of pod borer in chickpea. Therefore, the present study was planned and designed with the following objectives:

(i) To study the effect of sowing times on incidence and damage severity of pod borer on chickpea,

(ii) To study the biology of pod borer on chickpea in laboratory condition,

(iii) To determine effectiveness of Neem based botanicals on chickpea pod borer.

Chapter – II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The pod borer, *Helicoverpa armigera* (Hubner) is a serious pest of chickpea in Bangladesh and elsewhere in the world. Several studies in relation to different aspects of this pest have been reported from many countries of the world. For better understanding and management of this pest, efforts have been made to review the available literature related to this study.

2.1 Distribution of pod borer

Pod borer is a polyphagous pest, which spreads in wide geographical areas. The geographical range of *H. armigera* extends from Cape Verde Islands in the Atlantic, through Africa, Asia and Autralasia, to the South Pacific Islands and from Germany in the north to New Zealand in the south (Hardwick, 1965). Rao (1974) reported that in India, *H. armigera* is distributed over a wide range and caused serious losses to many crops, including chickpea, particularly in the semi-arid tropics. Ibrahim (1980) reported that *Heliothis* spp. is of considerable economic importance as pests on many Egyptian crops but *H. armigera* is the most abundant species throughout Egypt. Zalucki *et al.* (1986) cited that *H. armigera* was one of the widest distributions of any agricultural pests, occurring throughout Asia, Australia, New Zealand, Africa, southern Europe and many Pacific islands.

2. 2 Pest status and host range of pod borer

Bhatnagar and Davies (1978) recorded 50 species of crop plants and 48 species of wild and weed species of plants for *H. armigera* at Patancheru, Andhra Pradesh, India, whereas 96 crops and 61 weeds and wild species have been recorded elsewhere in India. The most important carryover weed hosts in the hot summer season are *Datura metel, Acanthospernium hispidum* and *Gynandropsis gynandra* for *H. armigera, H. assulta* and *H. pelligera.* Jayaraj (1962) reported that *Heliothis* could breed on a wide range of plants. The crops attacked in many countries were maize, sorghum, oats, barley, pearl millet, chickpea, pigeonpea, cowpea, peas, various beans, cotton, sunflower, safflower, tobacco, tomato, brinjal, cucurbits, sweet potato, groundnut, flax, citrus, sunhemp, potato etc.

Reed and Pawar (1981) cited that *H. armigera* was the dominant and primary pest of cotton, maize and tomatoes in some countries of Africa. Europe, America, Australia and Asia. In India, it was a dominant pest on cotton in some areas and in most of the areas, on several other crops particularly pigeon pea and chickpea. On both the major pulse crops, *H. armigera* commonly destroyed more than 50 of the yield. Garg (1987) studied the host range of *H. armigera* in the Kumaon Hills, India and found that larvae of *H. armigera* infested different plant parts of variety of crops like wheat, barley, maize, chickpea, pea, tomato, pigeonpea, lentil, onion and okra. He also pointed that chickpea appeared to be the most susceptible crop followed by pigeonpea, tomato and pea. In addition to these cultivated plants, it was also observed on some wild grasses and ornamental plants such as roses and chrysanthemums.

Marijunath *et al.* (1989) and Fitt (1991) reported that in the south Asian region, *Helicoverpa* was a serious pest of cotton, chickpea, pigeonpea, groundnut, cowpea, *Vigna* species, okra, tomato, castor, sunflower, maize, sorghum and many other crops.

2.3 Biology of pod borer

2.3.1 Host preference for oviposition

Parsons *et al.* (1937) reported that chickpea was most attractive for oviposition of pod borer. While, Reddy (1973) and Loganathan (1981) reported that pigeon pea was the preferred host for oviposition.

Vijayakumar and Jayaraj (1981) studied the preferred host plants for oviposition by *H. armigera* and found in descending order, pigeonpea > fieldpea > chickpea> tomato> cotton> chillics> mungbean> sorghum.

2.3.2 Mating and oviposition

Roome (1975) studied the mating activity of *H. armlgera* and repotted that from 02.00 to 04.00 hr the males flew above the crop while the females were stationary and released a pheromone. During this period males were highly active and assembled around females. Loganathan (1981) observed peak mating activity at 04.00 hr.

Singh and Singh (1975) found that the pre-oviposition period ranged from 1 to 4 days, oviposition period 2 to 5 days and post-oviposition period 1 to 2 days. Eggs were laid late in the evening, generally after 2100 hours and continued up to

midnight. However, maximum numbers of egg were laid between 2100 and 2300 hours. The moths did not oviposit during the daytime.

The eggs were laid singly, late in the evening, mostly after 2100 hr to midnight. On many host plants, the eggs were laid on the lower surface of the leaves, along the midrib. Eggs were also laid on buds, flowers and in between the calyx and fruit (Continho, 1965).

Tayaraj (1982) reported that oviposition usually started in early June, with the on set of pre-monsoon showers, adults possibly emerging from diapausing pupae and also from larvae that had been carried over in low numbers on crops and weeds during the summer. Reproductive moths were recorded through out the year ovipositing on the host crops and weeds with flowers. The pest multiplied on weeds, early-sown corn, sorghum, mung bean and groundnut before infesting pigeon pea in October-November and chickpea in November-March.

Zalucki *et al.* (1986) reported that females laid eggs singly or in groups of 2 or 3, on flowers, fruiting bodies, growing tips and leaves. During their two weeks life span, females laid approximately 1400 eggs.

Bhatt and Patel (2001) cited that the pre-oviposition period ranged from 2 to 4 days, oviposition period 6 to 9 days and post-oviposition period 0 to 2 days. Moth oviposited 715 to 1230 eggs with an average of 990.70 ± 127.40. While, Patel *et al.* (1979) reported that fecundity varied from 510 to 1676 and the average being 1142 ± 360.6 eggs.

2.3.3 Egg

The eggs of *H. armigera* are nearly spherical, with a flattened base, giving a somewhat dome-shaped appearance, the apical area surrounding the micropyles smooth, the rest of the surface sculptured in the form of longitudinal ribs, The freshly laid eggs are 0.4 to 0.55 mm in diameter, yellow-white, glistening, changing to dark brown before hatching .The incubation period of the eggs is longer in cold weather and shorter in hot weather, being 2 to 8 days in South Africa and 2.5 to 17 days in the United States (Pearson and Darling, 1958), and 2 to 5 days in India (Srivastava and Saxena, 1958; Singh and Singh, 1975).

2. 3. 4 Larva

The newly hatched larva is translucent and yellowish white in color, with faint yellowish orange longitudinal lines. The head is reddish brown, thoracic and anal shields and legs Brown and the setae dark brown. The full-grown larva is about 35 to 42 mm long; general body color is pale green, with one broken stripe along each side of the body and one line on the dorsal side. Short white hairs are scattered all over the body. Prothorax is slightly more brownish than meso and metathorax. Crochets are arranged in biordinal symmetry on the prolegs. The underside of the larva is uniformly pale. The general color is extremely variable; and the pattern may be in shades of green, straw yellow and pinkish to reddish brown or even black (Neunzig, 1964; Singh and Singh, 1975).

There are normally six larval instars in *H. armigera* (Bhatt and Patel, 2001), but exceptionally, during the cold season, when larval development is prolonged, seven instars wore regularly found in Southern Rhodesia (Pearson and Darling, 1958).

Temperature affects the development of the larva considerably. The larval duration varied from 21 to 40 days in California, 18 to 51 days in Ohio (Wilcox *et al.*, 1956), and 8 to 12 days in the Punjab, India (Singh and Singh, 1975) on the same host, tomato. The larval stage lasted for 21 to 28 days on chickpea (Srivastava and Saxena, 1958); 2 to 8 days on maize silk; 33.6 days on sunflower corolla (Coaker, 1959).

2.3.4 Pupa

The pupa is 14 to 18 mm long, mahogany-brown, smooth-surfaced and rounded both anteriorly and posteriorly, with two tapering parallel spines at the posterior tip (Singh and Singh, 1975). The pupa of *H. armigera* undergoes a facultative diapause. The non-diapause pupal period for *H. armigera* was recorded as 14 to 40 days in the Sudan Gezira, 14 to 57 days in Southern Rhodesia, 14 to 37 days in Uganda and 5 to 8 days in India (Jayaraj, 1982). According to Bhatt and Patel (2001) the pupal period ranged from 14 to 20 days in Gujarat, India.

2.3.5 Adult

The female *H. armigera* is a stout-bodied moth, 18 to 19 mm long, with a wingspan of 40 mm. The male is smaller, wing span being 35 mm. Forewings are pale brown with marginal series of dots; black kidney shaped mark present on the

underside of the forewing; hind wings lighter in color with dark colored patch at the apical end. Tufts of hairs are present on the tip of the abdomen in females (ICRISAT, 1982). The female lived long. The length of life is greatly affected by the availability of food, in the form of nectar or its equivalent; in its absence, the female fat body is rapidly exhausted and the moth dies when only 3 to 6 days old (Jayaraj, 1982).

The longevity of laboratory reared males and females were 3.13 ± 0.78 and 6.63 ± 0.85 days, respectively (Singh and Singh, 1975). According to Bhatt and Patel (200l), adult period in male ranged from 8 to 11 days with an average of 9.15 ± 0.90 days and in females 10 to 13 days with an average of 11.40 ± 0.91 days.

2.3.7 Generations

Hsu *et al.*, (1960) observed three generations of *H. armigera* each year in China. While, Reed (1965) reported that the pest completed four generations from September to March under western Tanganyika conditions. Singh and Singh (1975) reported that *H. armigera* passed through four generations in the Punjab, India; one on chickpea during March; two on tomato, from the end of March to May; and one on maize and tomato in July-August. Bhatnagar (1980) observed that seven to eight generations of *H. armigera* were present each year in Andhra Pradesh, India.

2.4 Effect of sowing dates on the incidence of pod borer

Yadava *et al.* (1983) suggested that early sowing of chickpea or the use of early maturing varieties could significantly reduce the damage caused by *H.*

armigera, because pod setting and maturation were completed during the period when larval population was low. Prasad *et al.* (1985) conducted an experiment on lie incidence of the noctuid *H. armigera* on chickpea at Bihar, India in 1979-81. The lowest pod damage, 8.7 and 11.3% as well as the highest yields, 15.3 and 14,0 q/ha respectively were recorded in the plot sown in November in both the years.

Dhurve and Borle (1986) cited that the pod damage in gram *(Cicer arietinum* L.) by *H. armigera* was the lowest when the crop was sown between 30th October and 4th December. The yield was significantly higher in 30 October and 27 November sowings. Talekar *et al.* (1991) observed that early November sowing of gram *(Cicer arietinum)* had the lowest number of eggs and larvae of *H. armigera* as compared with the sowing made 2 and 4 weeks later.

Begum *et al.* (1992) reported from an experiment conducted in Bangladesh mat sowing dates had significant influence on *H. armigera* in chickpea. They observed that chickpea sown on 15 November and 1 December suffered significantly less pod damage than those sown on 15 and 31 December.

2. 5 Botanicals in chickpea pod borer management

Butani and Mittal (1993) studied the efficacy of neem seed kernel suspension and several conventional insecticides against *H. armigera* on chickpea. All the tested insecticides significantly reduced the pest population and neem seed kernel suspension being equally effective. Sarode *et al.* (1994) studied the efficacy of different doses of neem seed kernel extract (NSKE) for the management of pod borer in chickpea. It

was found two sprays of (NSKE) 6% at 7 days interval provided significantly high larval reduction (69.45%) followed by two sprays of NSKE 5% (67.28%) and suggested that it may be used in managing *H. armigera* on chickpea. Jeyakumar and Gupta (1999) reported neem seed kernel extract (NSKE) reduced the oviposition of *H. armigera* in a dose dependent marine during the exposure periods of 0-24 h and 24-48 h and showed oviposition deterrency effect. Reduction of oviposition was highest (60.9%) with 10% NSKE. The hatchability of the laid eggs was also affected on NSKE treated surface.

Bajpai and Sehgal (2000) compared endosulfan with seven botanical insecticides, including neem, karanj *(Pongamia pinnata)* and tobacco formulations for control of pod borer on chickpea at Pantnagar, India. Endosulfan gave the highest pod borer control (40.2% pod damage} and yields. Of the botanicals, pod damage at maturity was lowest with karanj oil followed by the neem product Green Mark or nicotine sulfate and was highest with karanj oil. Neem *(Azadirachta Indica A. Juss)* seed oil, a botanical pesticide have also been used to control different insect pests of important agricultural crops in different countries of the world. More than 2000 species of plants have been reported to possess insecticidal properties (Grainge and Ahmed, 1988). The neem tree is one of them. The development and use of botanical pesticides become an integral part of the integrated pest management (IPM) strategies. Stoll (1992) summarized the potential benefits of botanical pesticides, which diminish the risk of resistance development natural enemy elimination, secondary out break of pest and ensure overall safty to the environment.

The seed and leaves of the neem tree contain terpenoids with potent anti-insect activity. One of the most active terpenoids in neem seeds is "azadirachtain" which acts as an antifeedant and growth disrupter against a wide range of insect pest at microgram levels. The active terpenoids in neem leaves include nimbin, deactylnimbin and thionemone (Simmonds *et al.*, 1992).

During last two decades neem oil and extracts from leaves and seeds have been evaluated as plant protect ant against a wide range of arthropod and nematode pests in several countries of the world. Although, most of the trails are laboratory based but it is not scanty in case of field condition. Ketkar (1976) reviewed 95 and Jacobson (1985) reviewed: 133 papers on neem and documented neem's potential in the management of arthropods pests (Warthen, 1979)

Ahmed and Grainge (1985) and Saxena (1988) summarized the effectiveness of neem oil against 87 arthropods and 5 nematodes, 100 insects and mites and 198 different species of insects respectively. Experiment with botanical pesticides has also been conducted in Bangladesh on a limited scale. Islam (1983) reported that extract of leaf, seed and oil of neem, showed potential as antifeedants or feeding and oviposition deterrents for the control of brown plant hopper, green leafhopper, rice hispa and lesser rice weevil. He also conducted experiments to asscertain the optimal doses of the extract against rice hispa, and pulse beetle. Addition of sesame or linseed oil to extract of neem resulted in higher mortality of the grubs and in greater deterrence in feeding and oviposition compared to those obtained with extract alone (Islam, 1986).

Field trail with neem products have shown, not only a decrease in damage by pest but also an increase in crop yield compared to those obtained with recommended synthetic insecticides. A methanol suspension of 2-4% of the neem leaves have been used against the caterpillar of diamondback moth, *Plutella xylostella* and it was as effective as either synthetic insecticides mevinphous (0.05%) or deltamethrin in (0.02%) in Togo (Dreyer, 1987). In Thailand, a field trail showed that piperanyl butoxide increased the efficacy of neem and the combination was as active as cypermethrin (0.025%) against *Plutella xylostella* and *Spodoptera litura,* which revealed that neem oil with synthetic insecticides, may have some synergetic effect in controlling insect pest (Sombatsiri and Tigvattanont, 1937). Fagoonee (1986) used neem in vegetable crop protection in Mauritius and showed neem seed kernel extract was found to be effective as deltamethrin (Decis) against the *Plutella xylostella* and *Crocidolomla binotalis.* He also found neen extract alternate with insecticides gave best protection against *Helicovarpa armigera.* Neem product have been used to control vegetable pest under field condition and good control of *Plutella xylostella* and Pyralid, *Hellula undalis* on cabbage was achieved with weekly application of 25 or 50 gm neern kernel powder/litre of water (Dreyer, 1986). The leaf extract of neem tested against the leaf caterpillar of brinjal *Selepa docilis.* Bult at 5% concentration had a high antifeedant activily with a feeding ratio of 20.29 followed by 3% having only medium antifeedant properties with 23.89 as the feeding ratio (Jacob and Sheila, 1994).

Entomologists of many countries including India, Philippines, Pakistan and Bangladesh have conducted various studies of neem against different insect pests. Most of the cases the investigators have been used a particular concentration of the neem extract, Neem seed kernel extracts (3-5%) were effective against *Nilaparvata lugens Nephotettix* spp., *Marasmia patnalis, Oxya nitidula* and Asian gall midge, Neem leaf extract, however, is less effective than neem seed kernel extract. But the same extract of 5-10% was highly effective, inclusive of *Scirpophaga incertulus* and thrips. Damage by leaf folders was reduced by 3% neem oil, Neem seed kernel extracts reduced egg deposition on rice seedling by *Nephotettix* spp. and *Nilaparvata lugens*. Neem seed kernel extract was an effective antifeedent to pigeon pea pod borer. He also found that there has been no adverse effect, even though neem was systemic. According to the neem oil can be used @ 1-3% without any problem. But 5% neem oil will cause phytotoxicity in many plants. The effect of neem oil is systemic, though not persistent. It should be noted that application of neem oil beyond 5% would cause serious phytotoxicity in rice. At 3%, the initial phytotoxicity effects are minimum and the plant can recover completely. Thus, neem oil should be applied at concentrations not beyond 3% (Jayaraj, 1991).

Most of the cases, the user of neem oil use it at different doses ranged from 0.5-50% (Krishnaiah and Kalode, 1991). They use different emulsifier to mixed neem oil with the water. Neem oil normally stays separately on the upper surface of the water. Detergent in water helps neem oil to emulsify in the water. In a field observation of neem oil Krishanaiah and Kalode (1991) used soap as emulsifier

with water although they have never mentioned the dose of the emulsifier in their trail. Another study with neem oil in rice field, Palanginan and Saxena (1991) added 1.66% teepol (liquid detergent) to the extract solutions as an emulsifier. In a study of Bangladesh Rice Research Institute (BRRI), Gazipur, Alam (1991) added 1 ml (0.1%) of teepol detergent per liter of water and spray at 7 days interval against stem borer of rice.

Chapter – III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiments were conducted to know the effect of sowing dates on infestation of chick pea pod borer, its biology and neem based botanicals management in the experimental farm of Sher-e-Bangla Agricultural University, Dhaka during rabi season and in the laboratory of the department of Entomology. The materials and methods used for conducting the experiments have been described in two sections. The first one described under general consideratios included a short description of location and season, soil type, climate, land preparation, fertilizer application, seed source, irrigation and intercultural operation, pod borer damage and statistical analysis of data. The second section provides laboratory oriented experimental description. Both the sections have been presented under the following sub headings-

3.1 General considerations

3.1.1 Location

The study was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^0 74'$N latitude and $90^0 35'$E longitude and an elevation of 8.2 m from sea level (Anon., 1989).

3.1.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil testing Laboratory, SRDI, Khamarbari, Dhaka.

3.1.3 Weather condition of the experimental site

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from November'07 to February'08 and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the metrological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka.

3.1.4 Land preparation

The soil was well prepared for ensuring good tilth in commercial crop production. The target land was divided into 36 equal plots (3 m × 2 m) with plot-to-plot distance 1m and block to block distance 0.5 m

3.1.5 Fertilizer application

Standard doses of fertilizers comprising N, P and K @ 40 kg, 25 kg and 25 kg per hectare in the form of urea, triple super phosphate and muriate of potash, respectively were applied as basal at the time of sowing seeds, and Urea finally top dressing before flowering stage.

3.1.6 Seed source and seed treatment

The Seeds of BARI (chola-5) of chickpea were collected from Bangladesh Agricultural Research Institute, Gazipur, Dhaka. Seeds were subjected to germination test before sowing. The rate of germination was found to be more than 90%. The seeds of chickpea were treated with Vitavax 200 @ 2 g/kg seed to protect seedlings against foot and root rot diseases.

3.1.7 Sowing of seeds

The seeds were first sown on 10 November 2007 in rows with spacing of 50 cm. The population of the plants was maintained constant by keeping plant-to-plant distance of 10 cm. The five sowing dates were November 20, 30, December 10, 20, and 30 of the year 2007.

3.1.8 Irrigation and intercultural operation

To avoid moisture stress and ensuring good germination, post-sowing irrigation was done. Intercultural operations like thinning, weeding and mulching were done as and when necessary for proper growth and development of the crop.

3.1.9 Determination of pod borer damage

All the pods were counted from 10 randomly selected plants from middle rows of each plot and examined. The damaged (bored) and total numbers of pods were counted and the percent pod damage was calculated using the following formula:

$$\% \text{ Pod damage} = \frac{\text{Number of damaged pod}}{\text{Total number of pod}} \times 100$$

3.1.10 Determination of percent pod infestation by number

After harvesting the healthy pods and the infested pods were separated by visual observation. The number of healthy pods and infested pods were counted and the percent pod initiation for each treatment was calculated by using the following formula:

$$\% \text{ Pod initiation by number} = \frac{\text{Number of infested pod}}{\text{No. of healthy pod} + \text{No. of infested pod}} \times 100$$

3.2 Statistical analysis of data

Data recorded on different parameters were processed for statistical analysis through computing the mean values in replicated form. Data were analyzed by using MSTAT-C software. The percent data were transformed by square root transformation. Mean comparisons for treatment parameters were compared using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

3.3 Biology of chickpea pod borer

The biology of chickpea pod borer was studied in the laboratory of the Department of Entomology Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar Dhaka - 1207, Bangladesh during 15 April to 30 June, 2008. The average daily room temperature and relative humidity were 29.71^{0}C and 72%, respectively.

3.4 Establishment of a lab culture of pod borer

Initial culture of *Helicoverpa armigera* was established in the laboratory by collecting larvae from a chickpea field. Those larvae were reared separately in glass petridishes (5.0 cm × 3.0 cm). Fresh twigs with leaves as well as pods of chickpea were provided daily in each petridish as food for the larvae. After completion of larval development, the larvae were transferred in poly bag containing soil for pupation. The pupal cocoon were collected and transferred into petridishes individually for the emergence of adults.

3.5 Studies on the incidence and damage severity of chickpea pod borer in filed

3.5.1 Treatments

There were 6 sowing dates with 10 days interval starting from 10th November to 30th December during rabi 2007. Each sowing date was considered as treatment to find

out the incidence and damage severity of pod borer in chickpea during the growing season.

T_1: Sowing on 10th November' 07

T_2: Sowing on 20th November' 07

T_3: Sowing on 30th November' 07

T_4: Sowing on 10th December' 07

T_5: Sowing on 20th December' 07

T_6: Sowing on 30th December' 07

3.5.2 Experimental design and layout

The experiments were laid out in randomized complete block design (RCBD) with three replications. The treatments were randomly allotted in each block. The unit plot size was 3m x 2m with a distance of 100 cm between the plots and 100 cm between the replications. In unit plots planting row to row distance was 50 cm and plant to plant was 10 cm.

3.5.3 Monitoring and data collection

The chickpea plants of different sowing dates were closely examined at regular intervals commencing from germination to harvest. The following data were collected during the course of the experiment.

The data on the first appearance of pod borer larvae in the field were recorded. Pod borer population per plant was recorded at weekly intervals from the randomly tagged 10 plants in central rows and starting from flowering to pod maturity. At maturity, percentage of pod damage due to pod borer was also calculated from the pods of 10 randomly selected plants from the central rows.

3.5.4 Harvesting and yield

The plants of middle three rows, avoiding border rows, of each plot were harvested. The pods were then threshed; grains were cleaned and dried in bright sunshine. The grain yield obtained from each plot was converted into yield per hectare

3.6 Application of different Neem based botanicals against pod borer of chickpea under laboratory condition

3.6.1 Treatments

Three neem products were used in different concentration as treatments. In this trial seven treatments were considered with a untreated control, which are given below:

T_1: Spraying with neem oil @ 0.5% + trix 5gm,

T_2: Spraying with neem oil @ 1.0% + trix 5gm,

T_3: Spraying with neem oil @ 1.5% + trix 5gm,

T_4: Sprayirg with neem seed kernel extract @ 0.5% + trix 5gm,

T_5: Sprayirg with neem seed kernel extract @ 1.0% + trix 5gm,

T_6: Sprayirg with neem seed kernel extract @ 1.5% + trix 5gm,

T_7: Spraying with neem leaf extract @ 50ml + trix 5gm and

T_8: Untreated control

3.4.2 Experimental design and layout

The experiment was laid out in complete randomized design (CRD) with three replications of each.

3.4.3 Monitoring and data collection

Initial culture of chickpea pod borer was established from the larvae of chickpea. Larvae were collected from the field and daily served fresh twig as food in the petridish (5 cm. x 3.0 cm). Larvae were sprayed with different neem based botanicals. After completion of

larval development, the larvae were transferred in poly bag containing moist soil for pupation. The pupae/cocoons were collected and transferred into petridish individually for the emergence of adults. Data were collected during the course of the experiment on larval and pupal length, breadth and weight. The duration of different life stages and larval mortality were also calculated.

3.7 Preparation of Neem based botanicals

3.7.1 Collection and preparation of Neem Oil

The neem oil was collected from Islampur market, Dhaka. Three concentration of spray material were prepared by neem oil @ 0.5% + trix 5gm, 1.0% + trix 5gm, and 1.5% + trix 5gm respectively.

3.7.2 Collection and preparation of Neem Seed Kernel Extract

Neem seed kernel was collected from Horticultural farm at Sher-e-Bangla Agricultural University. Neem seeds were crushed and mixed with 50 gm Neem seed kernel powder with 1000 ml water. Three concentrations of Neem seed kernel extracts were prepared and they were 0.5% + trix 5gm, 1.0% + trix 5gm, and 1.5% + trix 5gm respectively.

3.7.3 Collection and preparation of Neem Leaf Extract

Neem leaves were collected from Horticultural farm at Sher-e-Bangla Agricultural University. A solution of neem leaf extract was prepared with 1 kg of neem leaf and 3 liter of water. Here only the single concentration of insecticide was prepared and it was @ 0.5% + trix 5gm.

3.7.4 Antifeedant test

For antifeedant test 15 plants were encased with a mosquito net in the chickpea field. It was done to prevent the entrance of new population of chickpea pod borer from

surrounding plants. The antifeedant activity of pod borer was observed in the field of chickpea and different concentration of different neem products were used for this test.

3.5.5 Monitoring and data collection

The chickpea plants were closely examined at regular intervals. Daily data were collected and calculated from 10 randomly selected plants.

Chapter – IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to evaluate the effects of variation in sowing dates on chickpea, its biology and influence of neem based botanicals for the management of the pest under laboratory condition in experimental field of Sher-e-Bangla Agricultural University, Dhaka during Rabi 2007-2008. The results of pod damage by chickpea pod borer, larval and pupal duration, male and female life span, mortality of larvae and antifeedant activities of chickpea pod borer against botanicals have been presented, discussed and possible interpretations given under the following heading and sub-headings.

4.1 Biology of chickpea pod borer

4.1.1 Egg

The freshly laid eggs of chickpea pod borer were yellowish white in color, hemispherical in shape with a flattened base giving a somewhat dome-shaped appearance (Plate la). The length of the eggs varied from 0.42 to 0.48 mm with an average of 0.45 ± 0.003 mm whereas the breadth of the eggs varied from 0.46 to 0.52 mm with an average of 0.48 ± 0.004 mm (Table 1). The incubation period varied from 2 to 5 days with an average of 3.50 ± 0.15 days (Table 2).

4.1.2 Larva

The *Helicoverpa armigera* (Hubner) larva has six instars. The morphological description and average measurement of all larval instars of *H. armigera* are summarized below:

(a)

(b)

(c)

(d)

(e)

Plate1. Life stages of *Helicoverpa armigera* in chickpea, (a) egg (b) larva (c) prepupa (d) pupa and (e) adults

Table 1. Morphology of different life stages of chickpea pod borer during Rabi Season 2007-2008

Different life stage	Number of observation	Length (mm)			Breadth (mm)		
		Minimum	Maximum	Average±SE	Minimum	Maximum	Average±SE
Egg	15	0.42	0.48	0.45 ± 0.003	0.46	0.52	0.48 ± 0.004
Larva							
1st instar	15	1.10	1.80	1.45 ± 0.02	0.47	0.58	0.52 ± 0.005
2nd instar	15	3.10	6.60	4.85 ± 0.16	0.90	1.40	1.67 ± 0.03
3rd instar	15	8.20	16.4	12.3 ± 0.38	1.90	2.80	2.37 ± 0.06
4th instar	15	13.8	23.6	18.7 ± 0.43	2.20	3.10	2.51 ± 0.08
5th instar	15	16.2	27.9	22.1 ± 0.45	2.10	3.60	2.35 ± 0.05
6th instar	15	21.8	33.3	32.6 ± 0.57	3.60	4.80	4.20 ± 0.14
Pre-pupa	15	16.5	24.2	20.4 ± 0.42	3.90	5.15	4.37 ± 0.18
Pupa							
Male	15	12.8	18.8	15.7 ± 0.28	2.30	2.90	2.51 ± 0.08
Female	15	13.5	19.5	16.8 ± 0.26	3.13	3.50	3.31 ± 0.11
Adult							
Male	10	14.2	18.5	17.5 ± 0.31	28.8	34.0	31.4 ± 0.49
Female	10	15.5	23.2	19.5 ± 0.38	32.3	39.8	36.1 ± 0.63

Table 2. Duration of different life stages of chickpea pod borer reared in laboratory during Rabi season 2007-2008

Different life stage	Length (mm)		
	Minimum	Maximum	Average±SE
Egg	2	5	3.50 ± 0.15
Larval period			
1st instar	2	4	2.85 ± 0.13
2nd instar	2	4	2.77 ± 0.12
3rd instar	2	3	2.50 ± 0.10
4th instar	1	3	2.13 ± 0.07
5th instar	1	3	2.24 ± 0.08
6th instar	1	2	1.50 ± 0.05
Total larval period	10	19	14.33 ± 0.42
Pre-pupal period	1	3	1.89 ± 0.12
Pupal period	9	14	11.47 ± 0.36
Adult period			
Male	3	5	3.9 ± 0.26
Female	4	9	6.50 ± 0.31
Total life period			
Male	28	33	30.5 ± 0.48
Female	29	36	32.45 ± 0.53

First instar: The freshly emerged first instar larvae were translucent and yellowish white in color with black head (Plate 2a). The newly hatched larva was sluggish. However, it became active after 3 to 4 hours. The length of newly hatched first instar larvae varied from 1.1 to 1.8 mm with an average of 1.45 ± 0.02 mm and the breadth of newly hatched first instar larvae varied from 0.47 to 0.58 mm with an average of 0.52 ± 0.005 mm (Table 1). The duration of this instar varied from 2 to 4 days with an average of 2.85 ± 0.13 days (Table 2).

Second instar: The second instar larva was yellowish green in color (Plate 2b). The length of the larval body varied from 3.1 to 6.6 mm with an average of 4.85 ± 0.16 mm and the breadth of the larval body varied from 0.90 to 1.4 mm. with an average of 1.67 ± 0.03 mm. (Table 1). The duration of this instar taken from 2 to 4 days with an average of 2.77 ± 0.12 (Table 2).

Third instar: The third instar larva was green or brownish green in color. Head was light brown or light green in color (Plate 2c). The body length and breadth of the larva varied from 8.2 to 16.4 mm and 1.9 to 2.8 mm, respectively. Again, the average length and breadth of the body were 12.30 ± 0.38 mm and 2.37 ± 0.06 mm, respectively (Table 1). The instar lasted 2 to 3 days with an average of 2.50 ± 0.10 days (Table 2).

Fourth instar: The fourth instar larva was green or yellowish green or brownish green in color. Head was yellowish green or brownish green and thoracic legs are black but abdominal pro-legs were green or brown in color (Plate 2d). The body length and breadth of the larva ranged from 13.8 to 23.6 mm and 2.2 to 3.1 mm,

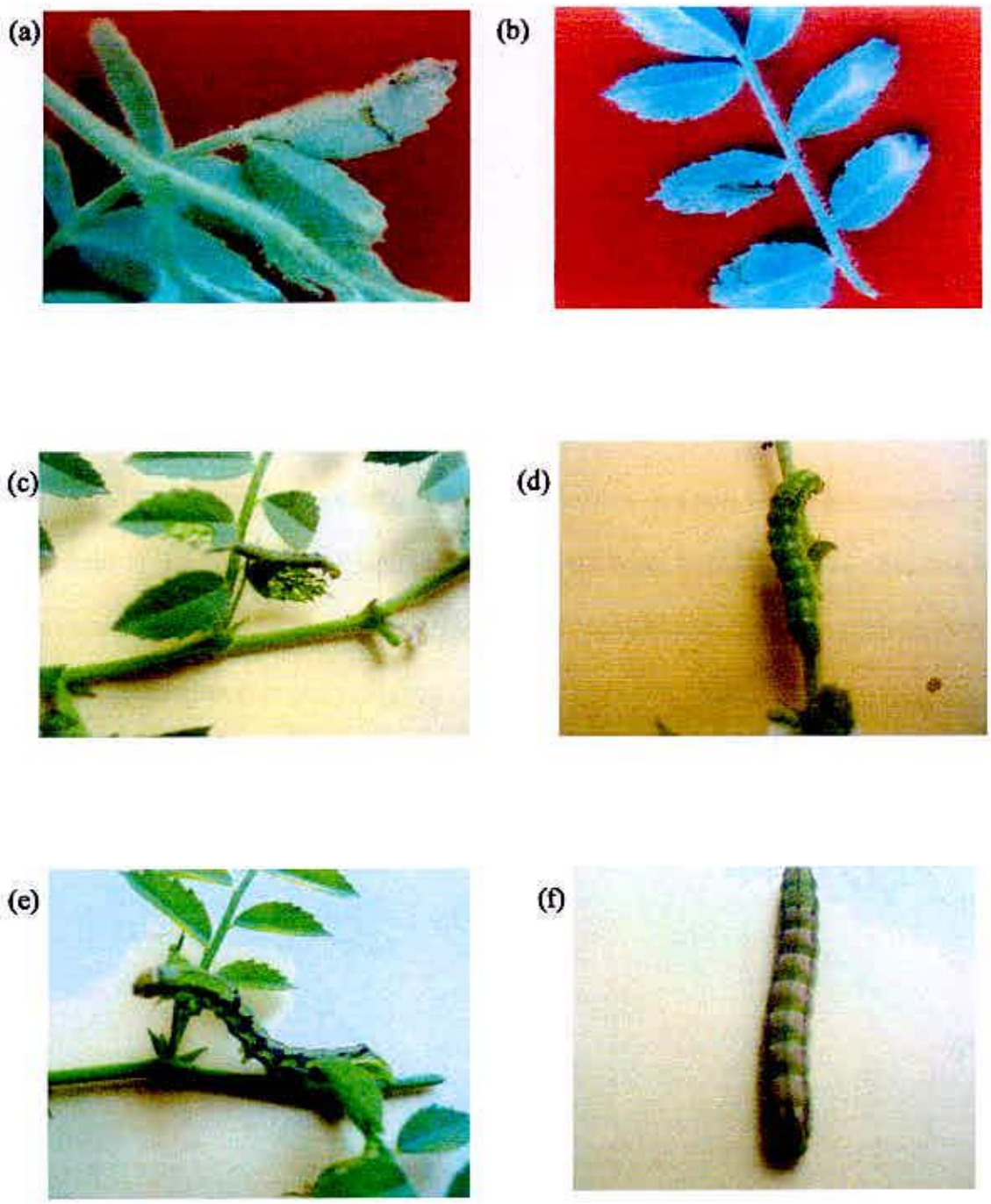

Plate 2. Larval instars of *Helicoverpa armigera*, (a) 1st instar (b) 2nd instar (c) 3rd instar (d) 4th instar (e) 5th instar and (f) 6th instar

respectively. The average length and breadth of the body were 18.70 ± 0.43 mm and 2.51 ± 0.08 mm, respectively (Table 1). This instar spent 1 to 3 days with an average of 2.13 ± 0.07 days (Table 2).

Fifth instar: The fifth instar larva was shiny green or shiny brown in color. Head was light brown or green in color (Plate 2e). The body length and breadth of the larva varied from 16.2 to 27.9 mm and 2.1 to 3.6 mm, respectively. The average length and breadth of the body were 22.10 ± 0.45 mm and 2.35 ± 0.05 mm, respectively (Table 1). The duration of this instar occupied from 1 to 3 days with an average of 2.24 ± 0.08 days (Table 2).

Sixth instar: The sixth instar larva was yellowish green, green, brownish green or brown in color. The general body color was brownish or pale green with lateral non-broken stripe along each side of the body and one distinct dorsal stripe. The larva was flattened ventrally but covex dorsally. Head was reddish brown or yellowish green (Plate 2f). The length and breadth of full-grown larva ranged from 21.8 to 33.3 mm and 3.6 to 4.8 mm, respectively with an average of 32.6 ± 0.57 mm and 4.20 ± 0.14 mm, respectively (Table 1). The duration of this instar ranged from 1 to 2 clays with an average of 1.50 ± 0.05 days (Table 2).

4.1. 3 Pre-pupa

In this stage the fully fed full-grown larva becomes sluggish, wrinkled and suspended both feeding and movement. The length and breadth of pre-pupal stage varied from 16.5 to 24.2 mm and 3.9 to 5.15 mm, respectively (Plate 1c) with an average of 20.40 ± 0.42 mm and 4.37 ± 0.18 mm, respectively (Table 1).

The duration of pre-pupal stage ranged from 1 to 3 days with an average of 1.89 ± 0.12 days (Table 2).

4.1.4 Pupa

Pupa was obtect type, broadly rounded anteriorly and tapered posteriorly. The freshly formed pupa was light green yellowish in color but later on turned into dark brown prior to emergence of moth (Plate 1d). In case of male pupa the length and breadth varied from 12.8 to 18.8 mm and 2.3 to 2.9 mm with an average of 15.7 ± 0.28 mm and 2.51 ± 0.08 mm, respectively. Again, in female it varied from 13.5 to 19.5 mm and 3.13 to 3.5 mm with an average of 16.8 ± 0.26 mm and 3.31 ± 0.11 mm, respectively (Table 1). The pupal duration ranged from 9 to 14 days with an average of 11.47 ± 0.36 days (Table 2).

4.1.5 Adult

Helicoverpa armigera (Hub.) is stout bodied moth, deep or dull brownish in color. Forewings were pale brown with a series of dots on margins and a black kidney shaped mark on the under side of each fore wing which was visible at the upper side with a big black doss (Plate 1e). The wavy markings were present on the body and abdomen. Brushes like tuft of hairs were present on the coxa and femur especially on mesothoracic legs. The female moth was slightly bigger than male and was identified by the presence of anal tuft of hairs. The length and breadth (with expanded wings) of male ranged from 14.2 to 18.5 mm and 28.8 to 34.0 mm, respectively while in case of female it was 15.5 to 23.2 mm and 32.3 to 39.8 mm, respectively. The male measured on an average 17.50 ± 0.31 mm in

length and 31.40 ± 0.49 mm in breadth and female measured on an average 19.50 ± 0.38 mm in length and 36.10 ± 0.63 mm in breadth (with expanded wings) indicating the female being bigger in size than male (Table 1). The longevity of male varied from 3 to 5 days with an average of 3.9 ± 0.26 days whereas; in female it varied from 4 to 9 days with an average of 6.50 ± 0.31 days (Table 2).

4.1.6 Duration of entire life span

The entire life span of adult male chickpea pod borer completed from egg to death varied from 28 to 33 days with an average of 30.5 ± 0.48 days whereas, in case of female it was 29 to 36 days with an average of 32.55 ± 0.53 days (Table 2).

4.2 Condition of chickpea against pod borer in different growth stage

At early, mid and late fruiting stage different sowing dates showed statistically significant differences for healthy and infested pod per plant by number. The results are presented in Table 3.

At early fruiting stage, the highest number of healthy pod per plant (50.33) was recorded from the treatment T_2 (Sown on 20th November'07) which was closely followed by the treatment T_1 (Sown on 10th November'07) (43.67). On the other hand, the lowest number of healthy pod (34.33) was recorded from the treatment T_6 (Sown on 30th December'07) which was statistically identical (36.33, 36. 67 and 37.33) with the treatment T_5 (Sown on 20th December'07), T_4 (Sown on 10th December'07) and T_3 (Sown on 30th November, 07), respectively. Considering the infested pod per plant, the highest number of infested pod (35.67) was recorded in

Table 3. Effect of different sowing dates on the incidence of pod borer at early, mid and late stage of plant growth by number during November, 2007 to April, 2008

Treatments	At early stage		At mid stage		At late stage	
	Healthy pod	Infested pod	Healthy pod	Infested pod	Healthy pod	Infected pod
T_1	43.67 b	16.33 c	42.33 b	20.67 c	34.67 b	21.33 c
T_2	50.33 a	10.67 d	52.00 a	10.33 d	47.00 a	11.33 d
T_3	37.33 c	20.67 b	37.67 c	24.67 b	37.67 b	25.67 b
T_4	36.67 c	18.33 bc	36.67 c	22.33 b	37.00 b	24.67 b
T_5	36.33 c	18.33 bc	36.67 c	23.33 b	37.33 b	24.33 b
T_6	34.33 c	35.67 a	34.00 c	35.00 a	34.33 b	33.33 a
$LSD_{(0.05)}$	5.199	3.404	3.593	3.816	4.149	2.818
CV(%)	7.18	9.35	4.95	9.23	6.00	6.61

In column, treatment means having the same letter(s) are significantly different by DMRT at 5% level of probability.

Values are the means of three replications.

T_1: Sowing on 10th November, 07

T_2: Sowing on 20th November, 07

T_3: Sowing on 30th November, 07

T_4: Sowing on 10th December, 07

T_5: Sowing on 20th December, 07

T_6: Sowing on 30th December, 07

from the treatment T_6 which was closely followed (20.67) by the treatment T_3. On the other hand, the lowest number of infested pod (10.67) was recorded from the treatment T_2 which was closely followed (16.33) by the treatment T_1 (Table 3).

The highest number of healthy pod per plant (52.00) was recorded from the treatment T_2 (Sown on 20th November'07) which was closely followed (42.33) by the treatment T_1 (Sown on 10th November'07) at mid fruiting stage. On the other hand, the lowest number of healthy pod per plant (34.00) was recorded from the treatment T_6 (Sown on 30th December'07), which was statistically similar (36.67 and 37.67) with the treatment T_5 (Sown on 20th December'07), T_4 (Sown on 10th December'07) and T_3 (Sowing on 30th November'07), respectively. Considering the infested pod per plant, the highest number of infested pod (35.00) was recorded from the treatment the T_6 (Sown on 30th December'07) which was closely followed (24.67, 23.33, 22.33) by the treatment T_3, T_5 and T_4, respectively. On the other hand, the lowest number of infested pod (10.33) was recorded from the treatment T_2 which was followed (20.67) by the treatment T_1 (Table 3).

At late fruiting stage, the highest number of healthy pod per plant (47.00) was recorded from the treatment T_2 (Sown on 20th November'07) which was closely followed (37.67, 37.33 and 37.00) by the treatment T_3 (Sown on 30th November'07), T_5 (Sown on 20th December'07) and T_4 (Sawn on 10th December'07), respectively. On the other hand, the lowest number of healthy pod (34.33) was recorded from the treatment T_6 (Sown on 30th December'07). Considering the infested pod per plant, the highest number of infested pod (33.33)

was recorded from the treatment T_6 (Sown on 30th December) which was followed (25.67, 24.67 and 24.33) by the treatment T_3, T_4 and T_5, respectively. On the other hand, the lowest number of infested pod per plant (11.33) was recorded from the treatment T_2 which was closely followed (21.33) by the treatment T_1 (Table 3).

From the above findings it was observed that in terms of total number of healthy pod per plant at different fruiting stage varied for different sowing dates and the highest was recorded for sowing time 20 November and it was the lowest in delay sowing dates i.e sowing on 30th December. On the other hand, total number of infested pod per plant was the highest in late sowing dates i.e sowing on 30th December' 07 and it was the lowest in sowing dates i.e. sowing on 20th November' 07. Yadava *et al.* (1983) reported that early sowing of chickpea or the use of early maturing varieties could significantly reduce the damage caused by *H. armigera.* Begum *et al.* (1992) also showed that sowing dates had significant influence on *H. armigera* in chickpea.

4.3 Effect of sowing dates on number of inflorescense, pod number and % pod infestation

The comparative effectiveness of different sowing dates on the number of inflorescence and pod per plant and percentage of pod infestation at early, mid and late fruiting stage are shown in Figure 1-3.

At early fruiting stage, the highest number (31.80) of inflorescence was recorded in the treatment T_6, followed by the treatment T_4 (27.10) and T_2 (26.23) respectively. On the other hand, the lowest number (21.00) of inflorescence was

found from the treatment T_5 which was statistically similar with the treatment T_3 (22.33). At mid fruiting stage, the highest number (38.75) of inflorescence was found in the treatment T_6 which was closely followed by the treatment T_4 (35.60) and T_5 (34.55), respectively. On the other hand, the lowest number (25.25) of inflorescence was found in the treatment T_3, followed by the treatment T_1 (28.21) and T_2 (29.10), respectively. At late fruiting stage, the highest number (48.25) of inflorescence was found in the treatment T_6, followed by the treatment T_5 (42.21) and T_2 (35.32), respectively. On the other hand, lowest number (31.00) of inflorescence was found in the treatment T_3 which was statistically identical with the treatment T_1 (32.25) (Figure 1).

From the above findings it was observed that the highest number of inflorescence per plant was recorded from the treatment T_6 (Sown on 30th December'07) for all fruiting stage and the lowest number of inflorescence per plant was recorded from the treatment T_3 (Sown on 30th November'07). Begum *et al.* (1992) reported similar findings earlier from their study.

At early fruiting stage, the highest number (70.00) of pod per plant was found in the treatment T_6 which was followed by the treatment T_2 (61.00) and T_1 (60.00) and the lowest number (54.66) of pod per plant was found in the treatment T_5 which was statistically similar with the treatment T_4 (55.00). At mid fruiting stage, the highest number (70.00) of pod per plant was found in the treatment T_6 which was followed by the treatment T_2 (62.67) and T_3 (62.33) and the lowest number (59.00) of pod per plant was found in the treatment T_4 which was

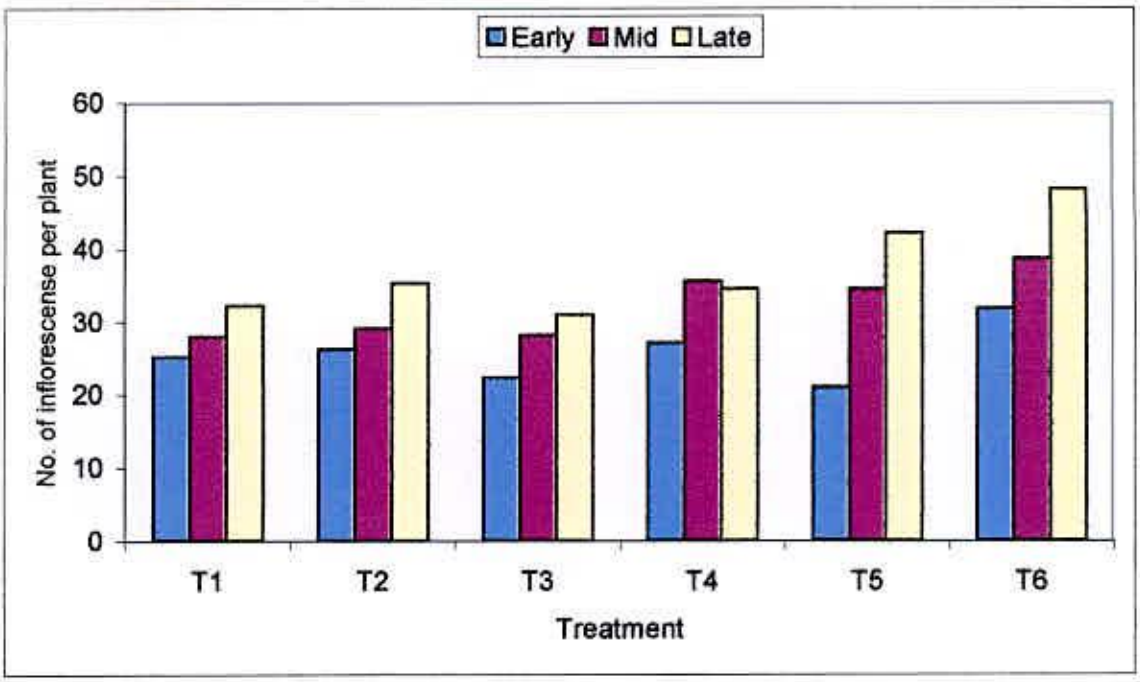

Figure 1. Effect of sowing dates on the number of inflorescence per plant in chickpea at different fruiting stages

T_1: Sowing on 10th November, 07

T_2: Sowing on 20th November, 07

T_3: Sowing on 30th November, 07

T_4: Sowing on 10th December, 07

T_5: Sowing on 20th December, 07

T_6: Sowing on 30th December, 07

statistically identical with the treatment T_5 (60.00). At late fruiting stage the highest number (67.67) of pod per plant was found in the treatment T_6 which was followed by the treatment T_3 (63.33) and the lowest number (56.00) of pod per plant was found in the treatment T_1 which was followed by the treatment T_2 (58.33) (Figure 2).

From the above findings it is observed that the highest number of pod per plant was recorded from the treatment T_6 (Sown on 30th December'07) for all fruiting stage and the lowest number of pod per plant was recorded from the treatment T_4 (Sown on 10th December'07) for all fruiting stage. Late sowing highest number of infested fruit with lowest healthy fruit whereas total was highest. Similar results were also observed by Yadava *et al.* (1983) and Prasad *et al.* (1985) in their study.

At early fruiting stage, the highest percent of pod infestation per plant (43.14%) was found in the treatment T_6 which was followed by the treatment T_3 (35.58%) and T_5 (33.27%) and the lowest percent of pod infestation (17.53%) per plant was found in the treatment T_1 that was followed by the treatment T_4 (27.55%) and the treatment T_2 (31.93%), respectively. At mid fruiting stage, the highest percent of pod infestation (52.35%) per plant was found in the treatment T_6, followed by the treatment T_5 (47.82%) and T_4 (44.53%) and the lowest percent of pod infestation (25.61%) per plant was found in the treatment T_1 which was followed by the treatment T_2 (37.53%) and T_3 (39.60%), respectively. At late fruiting stage, the highest percent of pod infestation (58.52%) per plant was found in the treatment T_6 which was followed by the treatment T_5 (53.31%) and T_4 (51.68%) and the

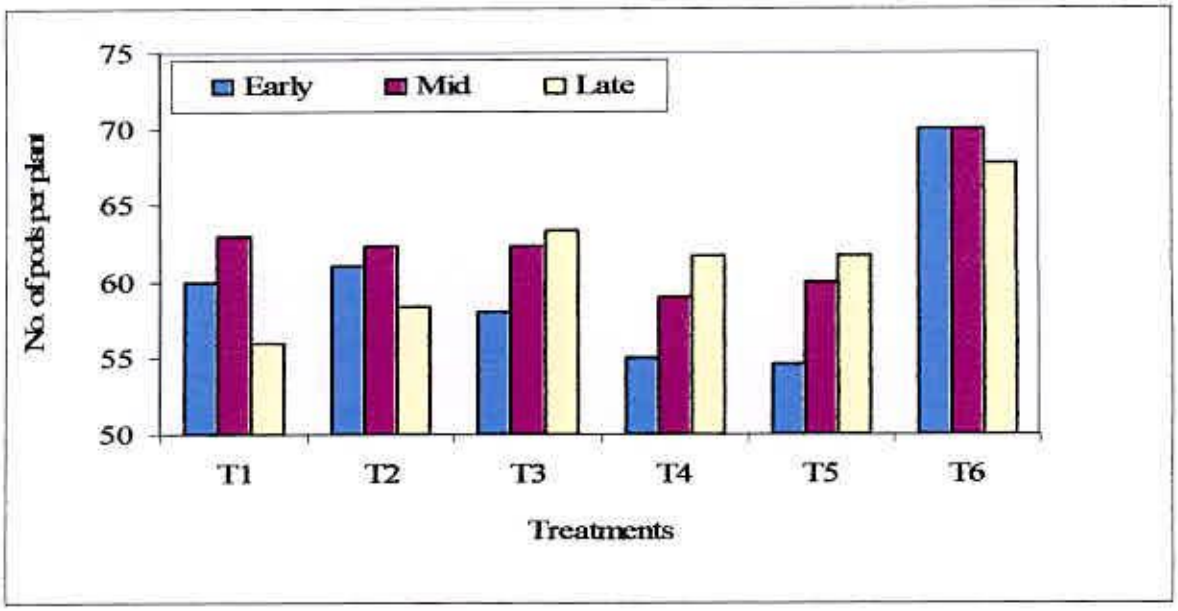

Figure 2. Effect of sowing dates on the number of pod per plant in chickpea at different fruiting stages

T_1: Sowing on 10th November, 07

T_2: Sowing on 20th November, 07

T_3: Sowing on 30th November, 07

T_4: Sowing on 10th December, 07

T_5: Sowing on 20th December, 07

T_6: Sowing on 30th December, 07

lowest percent of pod infestation (30.59%) per plant was found in the treatment T_1 which was followed by the treatmentT_2 (42.08%) and the treatment T_3 (45.94%), respectively (Figure 3).

From the above findings it is observed that the highest percent of pod infestation was recorded from the treatment T_6 (Sown on 30th December'07) for all fruiting stage and the lowest percent of pod infestation was recorded from the treatment T_1 (Sown on 10th November'07) for all fruiting stage. Similar works were also done by Dhurve and Borle (1986) in their study and they reported that pod infestation was the highest in the late fruiting stage.

4.4 Effect of sowing dates on total number of pod, pod damage and yield during the cropping season

Statistically significant variation was observed in terms of sowing dates to the effect on total number of pod, pod damage and yield of chickpea due to chickpea pod borer during the cropping season (Rabi) 2007-2008 and the details are presented in Table 4.

Considering the total number of pod, the highest number of pod (50.66) was recorded in the treatment T_2 (Sowing on 20th November'07) which was statistically similar (47.10) with the treatment T_5 (Sowing on 20th December'07), whereas the lowest number of pod (44.00) was recorded in the treatment T_6 (Sowing on 30th December'07) which was statistically identical (44.33) with the treatment T_1 (Sowing on 10th November'07).

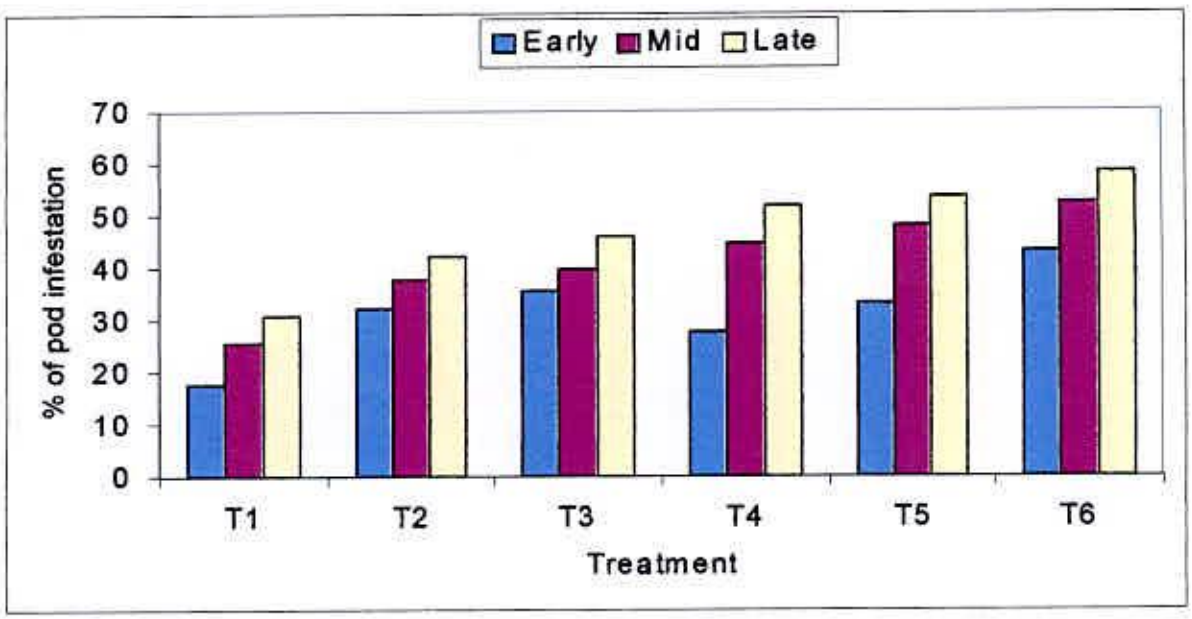

Figure 3. Effect of sowing dates on the %of pod infestation per plant in chickpea at different fruiting stages

T_1: Sowing on 10th November, 07

T_2: Sowing on 20th November, 07

T_3: Sowing on 30th November, 07

T_4: Sowing on 10th December, 07

T_5: Sowing on 20th December, 07

T_6: Sowing on 30th December, 07

Table 4. Effect of sowing dates on total number of pod and yield of chickpea during the cropping season (Rabi) 2007-2008

Treatments	Total number of pod	Pod damage (%)	Pod yield (kg/ha)
T_1	44.33 b	40.74 b	1495 a
T_2	50.67 a	31.80 c	1538 a
T_3	46.67 b	44.71 b	1350 b
T_4	46.33 b	41.88 b	1216 c
T_5	47.10 ab	44.67 b	1178 c
T_6	44.00 b	66.80 a	750 d
$LSD_{(0.05)}$	3.816	4.662	122.7
CV(%)	4.51	5.68	5.38

In column, treatment means having the same letter(s) are significantly different by DMRT at 5% level of probability.

Values are the means of three replications.

T_1: Sowing on 10th November, 07

T_2: Sowing on 20th November, 07

T_3: Sowing on 30th November, 07

T_4: Sowing on 10th December, 07

T_5: Sowing on 20th December, 07

T_6: Sowing on 30th December, 07

In terms of percent pod damage, the highest percentage of pod damage (63.80%) was recorded from the treatment T_6 (Sowing on 30th December'07) which was followed (44.71% and 44.67%) by the treatment T_3 (Sowing on 30th November'07),, T_5 (Sowing on 20th December'07) (44.67%) whereas the lowest number of pod damage (31.80%) was recorded from the treatment T_2 (Sowing on 20th November'07) which was followed (40.74%) by the treatment T_1 (Sowing on 10th November'07).

In terms of yield, the highest yield (1538 kg/ha) was recorded in the treatment T_2 (Sowing on 20th November'07) which was statistically similar (1495 kg/ha) with the treatment T_1 (Sowing on 10th November'07) and closely followed (1350 kg/ha) by T_3 (Sowing on 30th November'07). On the other hand the lowest yield (750 kg/ha) was recorded from the treatment T_6 (Sowing on 30th December'07) which was followed (1178 kg/ha) by the treatment T_5 (Sowing on 20th December'07) (Table 4).

From the above findings it was clearly observed that total number of pod was the highest in the sowing on 20th November' 07 whereas pod damage was the highest in late sowing dates i.e sowing on 30th December' 07. On the other hand, the highest yield was recorded in the early sowing date's i.e sowing on 20th November'07 whereas the lowest yield was recorded from the late sowing dates i.e sowing on 30th December'07. The results of the present study were more or less with the observation of Hossain (2006).

4.5 Effect of different neem based botanicals on the development of chickpea pod borer in laboratory

Significant differences were found on the effects of different neem based botanicals applied against chickpea pod borers in respect of growth and development of the larvae and pupae under laboratory condition are presented in Table 5-7.

4.5.1 Larval development

Larval length (mm): In terms of length of larvae, significant difference was observed due to the effect of different botanicals for 3rd and 4th instar but in 2nd instar it did not showed any significant differences. In 2nd instar, the highest (6.25 mm) length of full fed larvae was recorded from the treatment control plot T_8 whereas the lowest (6.04 mm) length of full fed larvae was recorded from T_1 comprising neem oil @ 0.5%. At third instar, the length of full fed larvae was the highest (15.50 mm) in T_8 (untreated control) which was followed by the treatment T_6 (13.82 mm), T_5 (13.43 mm), T_2 (13.10 mm) and T_7 (13.00 mm), respectively and the length of larvae was the lowest (10.73 mm) in T_3 comprising neem oil @ 1.5%. At 4th instar, the length of full fed larvae was the highest (22.17 mm) in T_8 (untreated control), which was statistically identical with the treatment T_7 (21.27 mm) and T_5 (20.97 mm). On the other hand, the length of larvae was the lowest (16.43 mm) in T_3 comprising neem oil @ 1.5% that was followed by the treatment T_1 (17.57 mm), T_2 (18.53 mm) and T_6 (18.67 mm), respectively (Table 5).

Table 5. Growth and development of the chickpea pod borer against the application of neem based botanicals

Treatment	Larval length			Larval breadth			Larval weight		Larval weight loss
	2nd instar	3rd instar	4th instar	2nd instar	3rd instar	4th instar	Pre-weight	Post-eight	
T_1	6.04	12.25 c	17.57 de	0.80 cd	1.67 c	2.21 d	3.08 cd	2.62 b	0.46 a
T_2	6.22	13.10 bc	18.53 cde	0.84 bc	1.78 c	2.12 d	3.20 bc	2.65 b	0.55 a
T_3	6.13	10.73 d	16.43 e	0.78 d	1.65 c	2.08 d	3.03 d	2.61 b	0.42 a
T_4	6.18	12.20 c	19.40 bcd	0.83bcd	1.77 c	2.26 d	3.30 ab	2.80 b	0.50 a
T_5	6.17	13.43 bc	20.97 abc	0.86 bc	1.81 c	2.52 c	3.22 ab	2.70 b	0.52 a
T_6	6.18	13.82 b	18.67bcde	0.88 b	1.76 c	2.63 c	3.31 ab	2.79 b	0.52 a
T_7	6.23	13.00 bc	21.27 ab	0.85 bc	2.02 b	2.96 b	3.22 ab	2.73 b	0.49 a
T_8	6.25	15.50 a	22.17 a	0.96 a	2.20 a	3.23 a	3.35 a	3.27 a	0.08 b
$LSD_{(0.05)}$	NS	1.262	2.486	0.055	0.145	0.232	0.122	0.263	0.205
CV(%)	3.03	5.61	7.41	4.12	4.46	5.32	2.27	5.51	6.60

In column, treatment means having the same letter(s) are significantly different by DMRT at 5% level of probability.

Values are the means of three replications.

T_1: Neem oil @ 0.5% + trix 5 gm

T_2: Neem oil @ 1.0% + trix 5 gm

T_3: Neem oil @ 1.5% + trix 5 gm

T_4: Neem seed kernel extract @ 0.5% + trix 5 gm

T_5: Neem seed kernel extract @ 1.0% + trix 5 gm

T_6: Neem seed kernel extract @ 1.5% + trix 5 gm

T_7: Neem leaf extract @ 50ml + trix 5 gm

T_8: Untreated control

Larval breadth (mm): Statistically significant variation was observed in terms of the breadth of larvae due to the effect of different botanicals. At second instar, the breadth of full fed larvae was the highest (0.96 mm) was recorded for T_8 (untreated control) which was closely followed by the treatment T_6 (0.88 mm), T_5 (0.86 mm), T_7 (0.85 mm), T_2 (0.84 mm) and T_4 (0.83 mm), respectively. On the other hand the breadth of larvae was the lowest (0.78 mm) in the leaf treated by T_3 comprising neem oil @ 1.5 % which was closely followed by the treatment T_1 (0.80 mm), respectively. At third instar, the breadth of full fed larvae was the highest (2.20 mm) in the treatment T_8 (untreated control), which was closely followed by the treatment T_7 (2.02 mm), while the breadth of larvae was the lowest (1.65 mm) in the leaf treated by T_3 comprising neem seed kernel extract @ 0.5% which was closely followed by the treatment T_1 (1.67 mm) and T_6 (1.76 mm), respectively. At fourth instar, the breadth of full fed larvae was the highest (3.23 mm) in the treatment T_8, which was closely followed by the treatment T_7 (2.96 mm) whereas the breadth of larvae was the lowest (2.08 mm) from T_3 comprising neem oil @ 1.0% which was statistically identical with the treatment T_2 (2.12 mm) and T_1 (2.21 mm), respectively. From the above findings, it was found that the larvae reached to its highest breadth in all instars when feed on untreated leaf as artificial food and in the succeeding instars larvae become bigger gradually (Table 5).

Larval weight (mg):

Significant difference was also observed in terms of the larval weight (mg) due to the effect of different botanicals.

Pre-weight: The highest pre-weight (3.35 mg) of full fed larva was recorded in the treatment T_8, which was statistically similar with the treatment T_6 (3.31 mg), T_4 (3.30 mg) and T_5 (3.22 mg), respectively. On the other hand, the lowest pre-weight (3.03 mg) of full fed larva was recorded in the treatment T_3, which was statistically similar (3.08 mg) with the treatment T_1 (Table 5).

Post-weight: The highest post-weight (3.27 mg) of full fed larva was recorded in T_8 (untreated control), which was followed by the treatment T_4 (2.80 mg), T_6 (2.79 mg) and T_7 (2.73 mg), respectively. On the other hand, the lowest pre-weight (2.61 mg) of full fed larva was recorded in the treatment T_3, which was closely followed by the treatment T_1 (2.62 mg), T_2 (2.65 mg) and T_5 (2.70 mg), respectively (Table 5).

Larval weight lost: Statistically significant difference was observed in terms of larval weight lost due to the effect of different botanicals. The highest larval weight loss (0.55%) was recorded from T_2 treatment and the lowest (0.08%) was recorded from T_8 treatment.

From the above findings it was observed that the highest length, breath and weight of full fed larvae was recorded in T_8 (untreated control) while the lowest length, breath and weight of full fed larvae was recorded in the treatment T_1 and T_3. So, considering the comparative effectiveness of different botanicals in respect of larval length, breath and weight it can be concluded that T_3 treatment comprising neem oil @ 1.5 % performed as the most effective treatment.

4.5.2 Pupal development

Pupal length: The highest pupal length (19.85 mm) was recorded in the treatment T_8 which was statistically similar with the treatment T_5 (19.50 mm), T_7 (19.37 mm) T_1 (19.07 mm), T_4 (18.94 mm) and T_6 (18.77 mm) whereas the lowest pupal length (15.77 mm) was recorded in the treatment T_3 (Table 6).

Pupal breadth: The highest pupal breadth (5.32 mm) was recorded in the treatment T_8 which was statistically similar with the treatment T_5 (5.34 mm), T_7 (5.06 mm), T_4 (5.05 mm) and T_6 (4.89 mm), respectively whereas the lowest pupal breadth (4.42 mm) was recorded from the treatment T_3 (Table 6).

Pupal weight: The highest pupal weight (2.13 mg) was recorded in the treatment T_8 followed by the treatment T_3 (1.40 mg), T_4 (1.34 mg), T_7 (1.33 mg) and T_1 (1.32 mg), respectively whereas the lowest pupal weight (1.06 mg) was recorded from the treatment T_2 (Table 6).

4.5.3 Effect of different neem based botanicals on duration of growth and development of chickpea pod borer in laboratory

Larval period: The larval period was expressed in days. The highest larval period (14.25±0.11) was recorded in the treatment T_8 (Untreated control) which was statistically similar with the treatment T_4 (13.53±0.34), T_7 (13.21±0.31), T_2 (13.14±0.21) and T_6 (13.02±0.38) whereas the lowest larval period (11.56±0.25) was recorded in the treatment T_3 (Table 7).

Table 6. Effect of different neem based botanicals on the pupal growth and development of chickpea pod borer in laboratory

Treatment	Pupal length (mm)	Pupal breadth (mm)	Pupal weight (mg)
T_1	19.07 a	4.63 bcd	1.32 b
T_2	18.63 a	4.57 cd	1.06 d
T_3	15.77 b	4.42 d	1.40 b
T_4	18.94 a	5.05 ab	1.34 b
T_5	19.50 a	5.34 a	1.11 cd
T_6	18.77 a	4.89 abc	1.27 bc
T_7	19.37 a	5.06 ab	1.33 b
T_8	19.85 a	5.32 a	2.13 a
$LSD_{(0.05)}$	1.914	0.428	0.164
CV(%)	5.90	5.02	6.75

In column, treatment means having the same letter(s) are significantly different by DMRT at 5% level of probability.

Values are the means of three replications.

T_1: Neem oil @ 0.5% + trix 5 gm

T_2: Neem oil @ 1.0% + trix 5 gm

T_3: Neem oil @ 1.5% + trix 5 gm

T_4: Neem seed kernel extract @ 0.5% + trix 5 gm

T_5: Neem seed kernel extract @ 1.0% + trix 5 gm

T_6: Neem seed kernel extract @ 1.5% + trix 5 gm

T_7: Neem leaf extract @ 50ml + trix 5 gm

T_8: Untreated control

Table 7. Effect of different neem based botanicals on duration of growth and development of chickpea pod borer in laboratory

Treatment	Larval period (days)	Pupal period (days)	Total life span (days)
T_1	12.21 bc ± 0.21	13.21 ab ± 0.21	26.23 bc ± 3.00
T_2	13.14 ab ± 0.14	13.31 ab ± 0.31	23.12 cd ± 1.12
T_3	11.56 c ± 0.00	11.17 c ± 0.17	21.28 d ± 0.72
T_4	13.53 ab ± 0.10	14.01 a ± 1.00	32.12 a ± 2.12
T_5	12.28 bc ± 0.28	12.11 bc ± 0.11	28.27 b ± 2.27
T_6	13.02 ab ± 0.02	13.15 ab ± 1.15	27.63 b ± 1.30
T_7	13.21 ab ± 0.21	13.24 ab ± 0.24	29.65 ab ± 1.30
T_8	14.25 a ± 2.00	14.14 a ± 0.86	32.23 a ± 1.77
$LSD_{(0.05)}$	1.254	1.112	3.176
CV(%)	5.61	4.93	6.66

In column, treatment means having the same letter(s) are significantly different by DMRT at 5% level of probability.

Values are the means of three replications.

T_1: Neem oil @ 0.5% + trix 5 gm

T_2: Neem oil @ 1.0% + trix 5 gm

T_3: Neem oil @ 1.5% + trix 5 gm

T_4: Neem seed kernel extract @ 0.5% + trix 5 gm

T_5: Neem seed kernel extract @ 1.0% + trix 5 gm

T_6: Neem seed kernel extract @ 1.5% + trix 5 gm

T_7: Neem leaf extract @ 50ml + trix 5 gm

T_8: Untreated control

Pupal period: The highest pupal period was recorded in the treatment T_8 (14.14±0.32) which was statistically similar with the treatment T_4 (14.01±0.3), T_2 (13.31±0.21), T_7 (13.24±0.28), T_1 (13.21±0.28) and T_6 (13.15±0.29), respectively. On the other hand the lowest pupal period (11.17±0.52) was recorded in the treatment T_3 (Table 7).

Total life span): The highest total life span (32.23±0.31) was recorded in the treatment T_8 which was statistically similar with the treatment T_4 (32.12±0.28) and T_7 (29.65±0.49), while the lowest total life span (21.28±0.23) was recorded from the treatment T_3 (Table 7).

The efficiencies of the botanicals were compared based on the length, breadth and weight of the larvae and pupae and total period of development. From the above discussion, it was observed that the maximum length, breadth and weight of larvae and pupae was recorded from T_8 (untreated control) and the minimum length, breadth and weight of larvae and pupae was recorded in T_3 comprising neem oil @ 1.5 %. Therefore, it was clearly observed that T_3 comprising Neem oil @ 1.5% + trix 5gm performed as the most effective treatment. About similar results were also found in the study conducted by Hossain (2006).

4.5.4 Effect of different neem based botanicals application at different DAT (days after treatment) on mean mortality (%) of chickpea pod borer larva, *Helicoverpa armigera*.

Significant differences were found in the percentage of mean mortality of chickpea pod borer larva treated with different neem based botanicals by topical application at different days after treatment are presented in Table 8.

Table 8. Mean Mortality (%) of chickpea pod borer larva, *Helicoverpa armigera* treated with different neem based botanicals by topical application at different DAT (interaction of neem based botanicals and time)

Treatment	Larval mortality (%)				Cumulative mortality (%)
	1st DAT	3rd DAT	5th DAT	7th DAT	
T_1	1.66 f	4.11 a	0.67 c	0.39 d	10.88 b
T_2	2.22 d	1.56 b	0.35 d	0.33 e	9.02 c
T_3	5.11 a	4.22 a	3.33 a	3.10 a	20.33 a
T_4	2.66 b	1.33 cd	0.33 e	0.33 e	7.43 de
T_5	2.44 c	1.22 d	0.33 e	0.67 c	7.65 de
T_6	2.67 b	1.33 cd	1.00 b	0.67 c	8.10 d
T_7	2.00 e	1.44 bc	0.33 e	1.00 b	7.21 e
T_8	0.00 g	0.67 e	0.00 e	0.00 f	3.00 f
$LSD_{(0.05)}$	0.190	0.122	0.017	0.055	0.789
CV(%)	5.12	4.61	3.26	6.30	5.73

In column, treatment means having the same letter(s) are significantly different by DMRT at 5% level of probability.

Values are the means of three replications.

T_1: Neem oil @ 0.5% + trix 5 gm

T_2: Neem oil @ 1.0% + trix 5 gm

T_3: Neem oil @ 1.5% + trix 5 gm

T_4: Neem seed kernel extract @ 0.5% + trix 5 gm

T_5: Neem seed kernel extract @ 1.0% + trix 5 gm

T_6: Neem seed kernel extract @ 1.5% + trix 5 gm

T_7: Neem leaf extract @ 50ml + trix 5 gm

T_8: Untreated control

At first days after treatment application, the highest percentage (5.11%) of larval morality was recorded from the treatment component T_3 comprising Neem oil @ 1.5% + trix 5gm followed by the treatment component T_6 (2.67%) comprising Neem seed kernel extract @ 1.5% + trix 5 gm, treatment component T_4 (2.66 %) comprising Neen seed kernel extract @ 0.5% + trix 5 gm and treatment component T_5 (2.44%) comprising Neem seed kernel extract @ 1.0% + trix 5 gm. On the other hand, the lowest percentage (0.00%) of larval morality was in treatment component T_8 (untreated control). At third days after treatment application, the highest percentage (4.22%) of larval morality was recorded from the treatment component T_3 which was statistically identical with the treatment component T_1 (2.11%), whereas the lowest percentage (0.67 %) of larval morality was recorded from T_8 (untreated control). At fifth days after treatment application, the highest percentage (3.33%) of larval morality was in the treatment component T_3 which was followed by the treatment component T_6 (1.00%), whereas the lowest percentage (0.00%) of larval morality was recorded from T_8 (untreated control). Again, at seventh days after treatment application, the highest percentage (3.10%) of larval morality was recorded from the treatment component T_3 which was closely followed by the treatment component T_7 (1.00%), whereas the lowest percentage (0.00%) of larval morality was recorded from T_8 (untreated control).

Considering the larval cumulative mortality, the highest percentage (20.33%) of morality was recorded from the treatment component T_3 that was followed by the treatment component T_1 (10.88%), T_2 (9.02%) and T_6 (8.10%), whereas the lowest percentage (3.00%) of larval cumulative morality was recorded in T_8 (untreated

control). It was clearly observed from the study that the trend of effectiveness of different treatments considering the larval cumulative mortality was $T_3 > T_1 > T_2 > T_6 > T_5 > T_4 > T_7$.

From the above findings it was observed that the treatment component T_3 comprising Neem oil @ 1.5% + trix 5gm performed as the best treatment and T_7 comprising Neem leaf extract @ 50ml + trix 5gm performed as the least effective treatment considering their effectiveness. Mehta *et al.* (1994), Datkhile *et al.* (1995), Chaudhary and Sachan (1995), Subbarayudu (1997) and Jadhav and Suryawanshi (1999) reported that the highest effectiveness of Neem oil @ 1.5 % against chickpea pod borer which are more or less similar with the present findings.

4.6 Antifeedant effect of different botanicals on chickpea pod borer larvae

Considering the antifeedant effect of different botanicals on chickpea pod borer larva, significant differences were found in the percentage of larval mortality treated with different neem based botanicals by topical application at different days after treatment are presented in Table 9.

At first days after treatment application, the percentage of larval morality was the highest (2.67%) in the treatment component T_3 comprising Neem oil @ 1.5% + trix 5gm which was closely followed by the treatment component T_1 (1.38%) comprising Neem oil @ 0.5% + trix 5gm, T_5 (1.35%) comprising Neem seed kernel extract @ 1.0% + trix 5gm and T_6 (1.33%) comprising Neem seed kernel extract @ 1.5% + trix 5gm. On the other hand, the lowest percentage of larval

Table 9. Antifeedant effect of different neem based botanicals (Neem oil, Neem seed kernel and neem leaf extract) on chickpea pod borer larva

Treatment	Larval mortality (%)				Cumulative mortality (%)
	1st DAT	3rd DAT	5th DAT	7th DAT	
T_1	1.38 b	1.10 c	0.67 c	0.35 d	6.00 b
T_2	1.18 bc	1.00 d	0.67 c	0.67 c	5.69 bc
T_3	2.67 a	2.53 a	2.00 a	2.20 a	11.67 a
T_4	0.67 d	0.33 f	0.67 c	0.33 d	4.67 e
T_5	1.35 b	0.67 e	1.33 b	0.21 e	5.22 d
T_6	1.33 b	0.38 f	0.67 c	0.38 d	5.38 cd
T_7	1.00 c	1.33 b	0.67 c	1.00 b	5.67 bc
T_8	0.00 e	0.00 g	0.33 d	0.00 f	2.00 f
$LSD_{(0.05)}$	0.305	0.095	0.205	0.077	0.406
CV(%)	16.41	6.45	15.53	7.70	4.44

In column, treatment means having the same letter(s) are significantly different by DMRT at 5% level of probability.

Values are the means of three replications.

T_1: Neem oil @ 0.5% + trix 5 gm

T_2: Neem oil @ 1.0% + trix 5 gm

T_3: Neem oil @ 1.5% + trix 5 gm

T_4: Neem seed kernel extract @ 0.5% + trix 5 gm

T_5: Neem seed kernel extract @ 1.0% + trix 5 gm

T_6: Neem seed kernel extract @ 1.5% + trix 5 gm

T_7: Neem leaf extract @ 50ml + trix 5 gm

T_8: Untreated control

morality was (0.00%) observed in T_8 (untreated control). At third days after treatment application, the highest percentage (2.53%) of larval morality was recorded from the treatment T_3 comprising Neem oil @ 1.5% + trix 5gm followed by the treatment T_7 (1.33%) comprising Neem leaf extract @ 50ml + trix 5gm. On the other hand, the lowest percentage of larval morality was (0.00%) recorded from T_8 (untreated control). At fifth days after treatment application, the highest percentage (2.00%) of larval morality was recorded from the treatment T_3 comprising Neem oil @ 1.5% + trix 5gm followed by the treatment T_5 (1.33%) comprising Neem seed kernel extract @ 1.0% + trix 5gm. On the other hand, the lowest percentage of larval morality was (0.33%) recorded from T_8 (untreated control). Again, at seventh days after treatment application, the highest percentage (2.20%) of larval morality was recorded in the treatment component T_3 comprising Neem oil @ 1.5% + trix 5gm which was closely followed by the treatment T_7 (1.00%) comprising Neem leaf extract @ 50 ml+ Trix 5 gm. On the other hand, the lowest percentage of larval morality was (0.00%) recorded from T_8 (untreated control).

Considering the larval cumulative mortality, the highest percentage (11.67%) of morality was recorded in the treatment T_3 followed by the treatment T_1 (6.00%), T_2 (5.69%), T_7 (5.67%) and T_6 (5.38%), whereas the lowest percentage (2.00%) of larval cumulative morality was recorded in T_8 (untreated control). It was clearly observed from the study that the trend of effectiveness of different treatments considering the larval cumulative mortality is $T_3 > T_1 > T_2 > T_7 > T_6 > T_5 > T_4$.

From the above findings it was observed that T_3 comprising Neem oil @ 1.5 % + trix 5gm performed as the best treatment while the treatment component T_4 comprising Neen seed kernel extract @ 0.5% + trix 5 gm performed as the least effective treatment considering their antifeedant effect. More or less similar works were done by Srimmannarayana *et al.* (1985), Prakash and Rao (1986) and Durairaj *et al.* (1991) to know the antifeedant properties of neem oil. This finding is also similar with other authors. Jacob and Sheila (1994) reported that the leaf extract of neem tested against the chickpea pod borer, *Helicoverpa armigera* Bult at 5% concentration had a high antifeedant activity with a feeding ratio of 28.29 followed by 3% having only medium antifeedant properties with 23.89.

Chapter – V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted to evaluate the effects of variation in sowing dates on chickpea, its biology and influence of neem based botanicals for the management of the pest under laboratory condition in experimental field of Sher-e-Bangla Agricultural University, Dhaka during Rabi 2007-2008. The sowing date was considered as treatment to find out the incidence and damage severity of pod borer in chickpea during the growing season. They were T_1: Sowing on 10th November' 07; T_2: Sowing on 20th November' 07; T_3: Sowing on 30th November' 07; T_4: Sowing on 10th December' 07' T_5: Sowing on 20th December' 07; T_6: Sowing on 30th December' 07. On the other hand application of Neem based botanicals were considered as treatments of the experiment which were: T_1: Spraying with neem oil @ 0.5% + trix 5gm; T_2: Spraying with neem oil @ 1.0% + trix 5gm; T_3: Spraying with neem oil @ 1.5% + trix 5gm; T_4: Sprayirg with neem seed kernel extract @ 0.5% + trix 5gm; T_5: Sprayirg with neem seed kernel extract @ 1.0% + trix 5gm; T_6: Sprayirg with neem seed kernel extract @ 1.5% + trix 5gm; T_7: Spraying with neem leaf extract @ 50ml + trix 5gm and T_8: Untreated control. The experiment was laid out in complete randomized design (CRD) with three replications of each. Data were collected during the course of the experiment on different growth parameters.

The average length and breadth of the eggs was 0.45 ± 0.003 mm and of 0.48 ± 0.004 mm with the average incubation period of 3.50 ± 0.15 days. The *Helicoverpa armigera* (Hubner) larva has six instars. The average length and

breadth of pre-pupal stage was 20.40 ± 0.42 mm and 4.37 ± 0.18 mm with average pre-pupal period of 1.89 ± 0.12 days. In case of male pupa the average length and breadth was of 15.7 ± 0.28 mm and 2.51 ± 0.08 mm. again, in female it was 16.8 ± 0.26 mm and 3.31 ± 0.11 mm.

At early fruiting stage, the highest number of healthy pod per plant (50.33) was recorded from the treatment T_2 and the lowest (34.33) was recorded from the treatment T_6. Considering the infested pod per plant, the highest number of infested pod (35.67) was recorded in from the treatment T_6 and the lowest (10.67) was recorded from the treatment T_2. The highest number of healthy pod per plant (52.00) was recorded from the treatment T_2 at mid fruiting stage and the lowest (34.00) was recorded from the treatment T_6. Considering the infested pod per plant, the highest number of infested pod (35.00) was recorded from the treatment the T_6 and the (10.33) was recorded from the treatment T_2. At late fruiting stage, the highest number of healthy pod per plant (47.00) was recorded from the treatment T_2 and the lowest (34.33) was recorded from the treatment T_6. Considering the infested pod per plant, the highest number of infested pod (33.33) was recorded from the treatment T_6 and the lowest (11.33) was recorded from the treatment T_2.

At early fruiting stage, the highest number (31.80) of inflorescence was recorded in the treatment T_6, and the lowest (21.00) was found from the treatment T_5. At mid fruiting stage, the highest number (38.75) of inflorescence was recorded in the treatment T_6 and the lowest (25.25) in the treatment T_3. At late fruiting stage,

the highest number (48.25) of inflorescence was found in the treatment T_6, and the lowest (31.00) in the treatment T_3. At early fruiting stage, the highest number (70.00) of pod per plant was found in the treatment T_6 and the lowest (54.66) in the treatment T_5. At mid fruiting stage, the highest number (70.00) of pod per plant was found in the treatment T_6 and the lowest (59.00) in the treatment T_4. At late fruiting stage, the highest number (67.67) of pod per plant was found in the treatment T_6 and the lowest number (56.00) in the treatment T_1. At early fruiting stage, the highest percent of pod infestation per plant (43.14%) was found in the treatment T_6 and the lowest (17.53 in the treatment T_1. At mid fruiting stage, the highest percent of pod infestation (52.35%) per plant was found in the treatment T_6 and the lowest (25.61%) was found in the treatment T_1. At late fruiting stage, the highest percent of pod infestation (58.52%) per plant was found in the treatment T_6 and the lowest (30.59%) in the treatment T_1.

Considering the total number of pod, the highest number of pod (50.66) was recorded in the treatment T_2, whereas the lowest (44.00) in the treatment T_6. In terms of percent pod damage, the highest percentage of pod damage (63.80%) was recorded from the treatment T_6 whereas the lowest (31.80%) from the treatment T_2. In terms of yield, the highest yield (1538 kg/ha) was recorded in the treatment T_2 and the lowest (750 kg/ha) was recorded from the treatment T_6.

Different neem based botanicals applied against chickpea pod borers in respect of growth and development of the larvae and pupae under laboratory condition. In 2^{nd} instar, the highest (6.25 mm) length of full fed larvae was recorded from the

treatment control plot T_8 whereas the lowest (6.04 mm) was recorded from T_1. At third instar, the length of full fed larvae was the highest (15.50 mm) in T_8 and the lowest (10.73 mm) in T_3. At 4^{th} instar, the length of full fed larvae was the highest (22.17 mm) in T_8 and the lowest (16.43 mm) in T_3. At second instar, the breadth of full fed larvae was the highest (0.96 mm) was recorded for T_8 and the breadth of larvae was the lowest (0.78 mm) in the leaf treated by T_3. At third instar, the breadth of full fed larvae was the highest (2.20 mm) in the treatment T_8, while the breadth of larvae was the lowest (1.65 mm) in the leaf treated by T_3. At fourth instar, the breadth of full fed larvae was the highest (3.23 mm) in the treatment T_8, whereas the lowest (2.08 mm) from T_3.The highest pre-weight (3.35 mg) of full fed larva was recorded in the treatment T_8, and the lowest (3.03 mg) of in the treatment T_3.

The highest post-weight (3.27 mg) of full fed larva was recorded in T_8 and the lowest (2.61 mg) in the treatment T_3. The highest larval weight loss (0.55%) was recorded from T_2 treatment and the lowest (0.08%) was recorded from T_8. The highest pupal length (19.85 mm) was recorded in the treatment T_8 whereas the lowest (15.77 mm) in the treatment T_3. The highest pupal breadth (5.32 mm) was recorded in the treatment T_8 and the lowest (4.42 mm) from the treatment T_3. The highest pupal weight (2.13 mg) was recorded in the treatment T_8 whereas the lowest (1.06 mg) from the treatment T_2. The highest larval period (14.25±0.11) was recorded in the treatment T_8 and the lowest (11.56±0.25) in the treatment T_3. The highest (14.14±0.32) pupal period was recorded in the treatment T_8 and the

lowest (11.17±0.52) in the treatment T_3. The highest total life span (32.23±0.31) was recorded in the treatment T_8, while the lowest (21.28±0.23) from T_3.

In case of the larval cumulative mortality for chickpea pod borer larva treated with different neem based botanicals the highest percentage (20.33%) of morality was recorded from the treatment component T_3, whereas the lowest (3.00%) was recorded in T_8. Considering the antifeedant effect of different botanicals on chickpea pod borer larva in case of larval cumulative mortality the highest percentage (11.67%) of morality was recorded in the treatment T_3, whereas the lowest (2.00%) was recorded in T_8.

Considering the situation of the present findings, following areas of study may be suggested for the future:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Another sowing date may be used for further study.
3. Other botanicals such as lantana leaf extract, marigold leaf extract, Bankolmi leaf powder etc. may be included for drawing conclusion.

Chapter – VI

Reference

CHAPTER VI
REFFERENCES

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Chapter – VII

Appendices

CHAPTER VII
APPENDICES

Appendix I. Monthly average Temperature, Humidity, Rainfall and Sunshine during the crop seasons of the experiments at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh.

Crop season rabi 2007-08						
Name	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Sunshine (Hour)
	Minimum	Maximum	Morning	Afternoon		
Nov. 07	17.41	28.82	96.17	82.47	000	7.71
Dec. 07	13.5	27.37	96.97	76.26	001	8.34
Jan. 08	10.42	24.68	94.81	94.45	000	7.06
Feb. 08	18.55	30.70	94.93	58.79	000	7.83
Mar. 08	22.55	33.63	88.77	44.77	002	8.54
Apr. 08	26.78	35.87	85.45	39.20	020	9.94

Source: Meteorological Station, Agargaa, Dhaka, Bangladesh.

Appendix II. Characteristics of SAU Farm soil are analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	SAU Farm, Dhaka
AEZ	Madhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fellow-lettuce

B. Physical and chemical properties of the initiol soil

Characteristics	Value
Partical size analysis	
% Sand	27
% Silt	43
% Clay	30
Texture class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeale K (me/100 g soil)	0.10
Available S (ppm)	45