ECOFRIENDLY MANAGEMENT OF CHICKPEA POD BORER (*HELICOVERPA ARMIGERA* HUBNER)

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ECOFRIENDLY MANAGEMENT OF CHICKPEA POD BORER (*HELICOVERPA ARMIGERA* HUBNER)

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CERTIFICATE

This is to certify that thesis entitled "ECOFRIENDLY MANAGEMENT OF CHICKPEA POD BORER (HELICOVERPA ARMIGERA **HUBNER***)" submitted to the* ***Faculty of Agriculture,*** *Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) IN ENTOMOLOGY, embodies the result of a piece of bona fide research work carried out by* ***MD. ELMUR REZA, Registration No. 12-05241*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2013
Place: Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED

PARENTS

ABBREVIATIONS AND ACRONYMS

AEZ	:	Agro-Ecological Zone
et al.	:	And others
BBS	:	Bangladesh Bureau of Statistics
cm	:	Centimeter
CV	:	Coefficient of variation
DAT	:	Days After Transplanting
^{o}C	:	Degree Celsius
d.f	:	Degrees of freedom
etc.	:	Et cetera
EC	:	Emulsifiable Concentrate
FAO	:	Food and Agriculture Organization
Fig.	:	Figure
g	:	Gram
ha	:	Hacter
p^H	:	Hydrogen ion conc.
J.	:	Journal
Kg	:	Kilogram
LSD	:	Least Significant Difference
L	:	Liter
m	:	Meter
MS	:	Mean sum of square
mm	:	Millimeter
MP	:	Murate of Potash
no.	:	Number
%	:	Percent
RCBD	:	Randomized Complete Block Design
SAU	:	Sher-e-Bangla Agricultural University
m^2	:	Square meter
t	:	Ton
TSP	:	Triple Super Phosphate

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Dated: December, 2013 **The Author**

SAU, Dhaka

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CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum L.*) is generally grown under rain fed or residual soil moisture conditions in rabi season after harvest of rice during October-March in Bangladesh. Among the major pulses grown in Bangladesh chickpea ranks fifth in area and production but second in consumption priority. It is a popular pulse crop in High Barind Tract (HBT) in the north-west of Bangladesh (within 24°20'-25°15'N, 88°15'-88°55'E). Chickpea is estimated to be grown on about 10,000 hectares of land in the HBT and is an important source of income and nutrition for resource-poor farm families (Musa *et al,.* 2002). The area sown for chickpea in Bangladesh has reduced from >100,000 ha during 1980s to around 15,000 ha in recent years (FAOSTAT 2007). This reduction is primarily attributed to the yield instability caused by pod borer (Rahman *et al*., 2000). Environmental conditions during the late vegetative and reproductive period for chickpea (February to mid-March) are particularly conducive to pod borer development.

The dry seed is a good source of protein and can he used as boiled whole seed. splited seed as "dal" and flour "bison" is also popular in Bangladesh. Besides providing protein in the diet of the people it also provide rich fodder to the cattle and serve the purpose of adding nitrogen and organic matter to the soil (Shaikh *et al.* 1980).

Generally more than 20 insect pests attack during various growth stages of chickpea plant. The gram pod borer is one of the important among them. The annual losses due to the insect pests of pulse crops accounts to 15 to 20 per cent or rarely 2.0 to 2.5 million tonnes in India (Katiyar, 1988). Gram pod borer (*Helicoverpa armigera* Hubner) is a key pest of chickpea (*Cicer arietinum L.*) causing 90-95% total damage (Saxena, 1978; Sachan and kathi, 1994).

The chickpea has relatively few insect pests but gram pod borer, *H. armigera* (Hubner) Hardwick is the major insect pest (Lal *et al*., 1985; Naresh and Malik, 1986; Lal, 1996). The pod borers inflicted great crop losses from seedling to maturity. But the losses reached at its peak when the pods appeared (Mehta and Singh, 1983; Deka *et al*., 1989). Lal (1996) reported that the seed yield losses due to *H. armigera* were 75-90% and in some places the losses were up to 100%. The yield loss in chickpea due to pod borer was reported as 10 to 60 per cent in normal weather conditions, while it was 50 to 100 per cent in favorable weather conditions, particularly in the state where frequent rain and cloudy weather is prevailing during the crop season (Patel, 1979). In favourable conditions pod borer may cause 90-95 per cent pod damage (Sachan and Katti, 1994). The young caterpillar of pod borer skeletonizes the leaves, while grown up caterpillar bores into the pods and feeds on the seeds. The losses can be reduced by the application of insecticides (Sinha *et al*., 1983; Singh *et al*., 1987; Rakesh *et al*., 1996; Balasubramanian *et al*., 2001).

In recent years, gram pod borer *(H. armigera)* also has developed resistance to certain molecules in all the established chemical groups of insecticides available to farmers now and field control failures are common in gram pod borer *(H. armigera).* Prolific use of synthetic insecticide created hazardous to environment and resulted resistance to insecticide in insects and killing natural enemies. Last few years endosulfan has been proved to be effective insecticide against gram pod borer gram pod borer *(H. armigera).* But studies from legume research (Suganthy *et al.,* 2002) revealed that endosulfan affected dwelling natural enemies severely, resulting 40% reduction of natural enemies. Therefore, to overcome this unfavourable situation less hazardous insecticides Deltamethrin (Decis 2.5 EC) was selected and emphasis has been given other alternative methods. Farmers are using botanical such as neem (*Azadirecta indica*) oil against gram pod borer (*H. armigera*).

Chemical insecticides are generally used in pod borer control due to their effectiveness and easy availability. Recently, *H. armigera* is reported to have developed resistance to many commonly used insecticides (Lande, 1992). In past, the best insecticide was reported to be the cypermethrin (Gohokar *et al.,* 1985; Singh *et al.,* 1987; Khan *et al.,* 1993; Jadhav and Suryawanshi, 1998) and endosulfan (Chaudary *et al.,* 1980; Rizvi *et al.,* 1986). Phokela *et al.,* (1990) observed a tendency of increased resistance to cypermethrin in the population of *H. armigera.* Moderate to high levels of resistance to cypermethrin and moderate resistance to endosulfan were recorded in field populations of *H. armigera* (Ahmad *et al*., 1995).

In many trails lamdacyhalothrin performed well to control pod borer. Farmers generally sprayed insecticides at full podding or pod maturing stage when full-grown pod borer are visible on the plant with boring pods. As a result the grown up pod borers are not killed moreover it creates environmental pollution, left residual toxicants, kill natural enemy, cause resurgence, upset etc.

Botanicals degrade rapidly from sunlight, air, and proper moisture, which generally makes them less toxic to the environment, but may also require them to be applied more often, applied correctly, and with more precise timing. It also acts quickly to stop feeding of insect pests and often cause immediate paralysis or cessation of feeding, but they may not cause the insect’s death for hours or days. Most botanicals have low to moderate toxicity to mammals, yet they are still poisons and pose a hazard to humans or to the environment. Most botanicals are not toxic to plants, except insecticidal soaps. Botanical plant products are less expensive, readily available, environmentally safe and less hazardous in comparison to chemical insecticides (Sexana *et al.*, 1980). The main advantages of botanicals are that they are easily produced and used by farmers in small scale industries.

Objectives:

Considering above points the experiment have been undertaken to fulfill the following objectives:

1. To study on the infestation intensity of chick pea pod borer among different management practices.
2. To find out the efficacy of different management practice against chick pea pod borer.

CHAPTER II

REVIEW OF LITERATURE

Chickpea *(Cicer arietinum L.)* is one of the important pulses in Bangladesh. It is used in various forms such as grain for human consumption, fodder for cattle, *green* manure, Cover crop and a short-lived forage but gram pod borer is a key pest of chickpea causing 90-95% total damage.

2.1 Nomenclature

Gram pod borer *Helicoverpa armigera* (Hubner) is a polyphagous insect, belonging to the family Noctuidae of the order Lepidoptera. There are several genera under this family, and the genus *Helicoverpa* contains more number of species, including *H. armigera* which is the serious pest of chickpea (Mishra *et al*., 1996).

2.2 Synonym

Heliothis armigera (Hubner)
Helicoverpa zea (Boddie)
Helicoverpa punctigera (Wallengren)
Helicoverpa assulta (Guenee)
Heliothis virescens (Fabricius)
Heliothis viriplaca (Hufnagel)
Hehothis peltigera (Denis & Schiffermuller)

2.3 Common name: American boll worm

2.4 Systematic position

Phylum: Arthropoda
Class : Insecta
Order : Lepidoptera
Family : Noctuidae
Genus : *Helicoverpa*
Species :*Helicoverpa armigera* (Hubner)

2.5 Origin and Distribution

Gram pod borer is a versatile and widely distributed polyphagous insect. Besides Bangladesh, this pest occurs in Southern Europe, probably the whole of Africa, the middle East, India, Central and South East Asia to Japan, the Philippines, Indonesia, New Guinea, the eastern part of Australia, New Zealand and a number of pacific islands except for desert and very humid region (Singh, 1972). Zalucki *et al.,* (1986) reported 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. Pod borer is a polyphagous pest, which spreads in wide geographical areas and it 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) stated 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) observed that *Heliothis* spp. is of considerable economic importance as pests on many Egyptian crops but *H. armigera* is the most abundant species throughout Egypt.

Helicoverpa armigera has one of the widest distributions of any agricultural pest, occurring throughout Pakistan, India, Central Asia (former USSR states), southeastern Asia (China, India, Pakistan, Thailand), Africa, Middle east, southern Europe (Spain, Portugal, Turkey and Greece), eastern and northern Australia, New Zealand and many eastern pacific Islands (Mohyuddin, 1985; Common, 1953; Hardwick, 1985; Zalucki *et al.*, 1986). Economic losses, both from direct yield reduction and from the cost of chemicals, application, and scouting required to control them, may be considerable. Annual estimates of damage include US $ 300 million only in Indian legumes by *H. armigera* (Reed and Pawar, 1982). The level of damage to other crops varies greatly throughout the world and among species, making generalization difficult.

The pod borer, *H. armigera* and the aphid, *A. craccivora* are the major pests of chickpea in the Indian Subcontinent. In the Mediterranean region, the most important pest is the leaf miner, *L. cicerina*. The black aphid, *A. craccivora* is important as a vector of the chickpea stunt disease, while *C. chinensis* is the most dominant species in storage. In Australia, the major pests of hickpea are the two pod borers, *H. armigera* and *H. punctigera* (Knights and Siddique, 2002). Chickpea has a few pest problems in the USA (Miller *et al*., 2002; Margheim *et al*., 2004; Glogoza, 2005). Occasional pests in the Pacific Northwest are the western yellow striped armyworm, *S. praefica* (Grote) (Clement, 1999), pea leaf weevil, *Sitona lineatus* (L.) (Williams *et al*., 1991), pea aphid, *A. pisum* and cowpea aphid, *A. craccivora* (Clement *et al*., 2000). The potential pests are early season cutworms, loopers, corn earworm (*H. zea*), wireworms, aphids, grasshoppers and an agromyzid leafminer. Larvae of the agromyzid fly mine the chickpea leaves, but the impact of damage has not been established (Miller *et al*., 2002; Margheim *et al*., 2004).

2.6 Host range

A wide range of host crops plants occur including cotton, tobacco, maize, sorghum, pennisetum, sunflower, various legumes, citrus, okra and other horticultural crops.Wild plants considered important include species of Luphorbiaceae, Amaranthaceae, Malvaceae, Solanaccac, Compositae, Portulacaceae and Convolvulaceae, but many other plant families are also reported to be hosts (Jiirgen *et al.*, 1977). Reed and Pawar (1982) observed 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 the 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 out 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. Bhatnagar and Davies (1978) reported that 50 species of crop plants and 48 species of wild and weed species of plants found for attacking by *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 *Daturametel, 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, oat, barley, pearl millet, chickpea, pigeonpea, cowpea, pea, various bean, cotton, sunflower, safflower, tobacco, tomato, brinjal, cucurbits, sweet potato, groundnut, flax, citrus, sunhemp, potato etc.

2.7 Status and nature of damage of gram pod borer

Pod borer *Helicoverpa armigera* is one of the major pest of gram, it started to attack early stage and become severe maturity stage of crop. The pest accounts for 90-95% on total damage (Sahan and Kathi, 1994 and Sitanathan *et al*, 1983). A single larva of *H. armigera* can damage 25-30 pods of gram in its life time (Sharma, 1978). It feeds on tender shoots and young pods (Lal, 1996). The make holed in pods and insert their half body inside the pod to eat the developing seeds (Kadam and Patel., 1960)

The pod borers inflicted heavy crop losses from seedling to maturity. But the losses reached at its peak when the pods appeared (Mehto and Singh 1983, Deka *et al*. 1989). Lal (1996) reported that the seed yield losses due to *H. armigera* were 75-90% and in some places the losses were up to 100%. The yield loss in chickpea due to pod borer was reported as 10 to 60 per cent in normal weather conditions, while it was 50 to 100 per cent in favorable weather conditions, particularly in the state where frequent rain and cloudy weather is prevailing during the crop season (Patel 1979).These losses can be reduced by the application of insecticides (Sinha *et al*., 1983; Singh *et al*., 1987; Rakesh *et al*., 1996; Balasubramanian *et al*., 2001). In favourable conditions pod borer may cause 90-95 per cent pod damage (Sachan and Kathi, 1994).

Chickpea production is severely threatened by increasing difficulties in controlling the pod borers, *H. armigera* and *H. punctigera* (Matthews, 1999). The extent of losses due to *H. armigera* in chickpea have been estimated to be over $328 million in the semi-arid tropics (ICRISAT, 1992). Worldwide, losses due to *Heliothis/Helicoverpa* in cotton, legumes, vegetables, cereals, etc. may exceed $2 billion, and the cost of insecticides used to control these pests may be over $1 billion annually (Sharma, 2005). Field surveys in the early 1980s indicated that less than 10% of the farmers used pesticides to control *H. armigera* in chickpea in India (Reed *et al*., 1987). However, the shift from subsistence to commercial production and the resulting increase in prices have provided the farmers an opportunity to consider application of pest management options for increasing chickpea production (Shanower *et al*., 1998).

The legume pod borer is one of the largest yield reducing factors in food legumes. Its serious pest status has mainly been attributed to the high fecundity, extensive polyphagy, strong dispersal ability, and a facultative diapause. The larval preference for feeding on plant parts rich in nitrogen such as reproductive structures and growing tips results in extensive crop losses (Fitt, 1989).

2.8 Biology

Tripathi and Sharma (1985) studied on host preference of *Helicoverpa armigera* on six food plants such as chickpea *Cicer arietinum.* They concluded that *C. arietinum* was the most preferred plant and completed its life cycle comparatively short time than other hosts.

Dhandapani *et al.,* (1984) reported that life tables of *Heliothis armigera* on chickpea at 26 ± 20C. The net reproductive rate (Ro) representing the total female births was 140.63. The population increased with an intrinsic rate of 0.1190 and a finite rate of 1.127/female per day. A generation was completed in 14.57 days.

Yadava and Lal (1988) stated that the changes in the larval population of the noctuid *Heliothis armigera [H. armigera]* were studied on chickpeas [*C. arietinum*] in Uttar Pradesh, India. There were 2 peaks in the population during the 47th to 50th and 11th to 15th weeks. Population was positively correlated with maximum and minimum temperatures and negatively correlated with relative humidity and percentage parasitism by the ichneumonid Campoletischlorideae.

Kashyap and Dhindsa (1990) conducted the experiment that the biolocry of *Heliothis armigera* on pigeon pea *Cajanus cajan* in the laboratory. The egg stage lasted 2.7 days at 19.5-27.50C during October-November and 5.9 days at 1*3.2-18.5^{0}C* in December. There were 5 larval instars at 19.5-22.50 with respective durations of 1.50, 2.87, 3.33, 4.46 and 7.00 days. The preoviposition period was 2.4 days in October-November and 5.4 days in December.

Srivastava *et al., (1990)* studied on antibiosis in the *Cicer arietinum* genotypes against *Heliothis armigera* [*H. armigera]* was studied in the laboratory. He found that the longevity of *H. armigera* varied between 8-10 and 10-12 days for males and females.

The effects of food plants on the different life stages (Chowdhury *et al.,* 1993) of *H. armigera* were investigated in the laboratory. Larval and pupal periods differed with food plants, the larval period was least on chickpeas. While pupal period was least on pigeon peas. Weight of 6th-instar larvae and mature pupae also differed with food plants. Percentage larval survival and percentage pupation were greatest on chickpea and least on sweet.

Singh and Mullick (1997) reported that the effect of chickpeas, cowpeas, black gram [*Vigna mungol*] and pigeon peas on the development and survival of *Helicoverpa armigera* studied when reared larvae of *H.* armigera passed through 6 insters on all leguminous plants. They started that the mean development period was the longest on black gram and the shortest on cowpeas.

Maximum survival rate was observed on chickpeas and the smallest on pigeon peas. Greatest mortality of larvae (46%) on pigeon peas Was recorded during the 1st instar. Leaves of different plants had no effect on the development period of pupae. However, significant effects of larval food on survival rates of pupae *were* observed. The number of pupae which failed to emerge into adults was the lowest on cowpeas and the greatest on pigeon peas. The development index value for chickpeas and cowpeas were similar and significantly greater than for black gram and pigeon peas. Pigeon peas were the least suitable for growth and development of *H. armigera.*

H. armigera is fruit feeder, though leaves of crops such as potato and tobacco undergo most damage. Consequently, they are in direct competition with humans for food and fiber. Fruit parts fed by larvae are either rendered unusable or greatly reduced in quality and feeding often facilitates infection by pathogenic organisms. It is a multivoltine with diapause, highly fecund and capable of moving long distances as adults (Fitt, 1989). Thus, they can rapidly exploit host crops, particularly monocultures. Another important factor contributing to its pest status is the relatively large size and quick development. It completes development from egg to adult in less than 30 days; consequently, food is consumed at a high rate.

Biological control occurs in nature when populations are limited through the action of parasites, predators and pathogens. As an applied science, biological control often involves releases of exotic natural enemies in *an* attempt to suppress introduced pest species, but it is also implemented through the augmentation or conservation of natural enemies. Hundreds of successful biological control projects have subsequently been carried out around the world. Biological control stands today as a cornerstone of integrated pest management (IPM) and is the foremost alternative to the use of chemical pesticides (Greathead, 1986; Wratten, 1987; DeBach end Rosen, 1991). Successful projects demonstrate the circumstances under which natural enemies play an important role in the regulation of host populations; failures highlight questions concerning a range of ecological issues including the dynamics of predator-prey and parasite host interactions, colonization events, competition and community structures (Haffaker *et al.*, 1976;. Hussel 1986; Luck *et al.*, 1988). Indeed attempts to explain and remedy failures of biological control often serve as the impetus for considerable research on the ecology and basic biology of the systems involved (Mohyuddin, 1981).

2.9 Host plant-resistant

The development of crop cultivars resistant or tolerant to *H. armigera* has a major potential for use in integrated pest management, particularly under subsistence farming conditions in the developing countries (Fitt, 1989; Sharma and Ortiz, 2002). More than 14,000 chickpea germplasm accessions have been screened for resistance towards *H. armigera* at ICRISAT, Hyderabad, India, under field conditions (Lateef and Sachan, 1990). Several germplasm accessions (ICC 506EB, ICC 10667, ICC 10619, ICC 4935, ICC 10243, ICCV 95992 and ICC 10817) with resistance to *H. armigera* have been identified, and varieties such as ICCV 7, ICCV 10 and ICCL 86103 with moderate levels of resistance have been released for cultivation (Gowda *et al*., 1983; Lateef, 1985; Lateef and Pimbert, 1990). Pedigree selection appears to be effective in selecting lines with resistance to *Helicoverpa*. However, most of these lines are highly susceptible to fusarium wilt. Therefore, concerted efforts are being made to break the linkage by raising a large population of crosses between *Helicoverpa* and wilt resistant parents. Wild relatives of chickpea are an important source of resistance to leaf miner, *L. cicerina* and the bruchid, *C. chinensis* (Singh *et al*., 1997). Based on leaf feeding, larval survival and larval weights, accessions belonging to *C. bijugum* (ICC 17206, IG 70002, IG 70003, IG 70006, IG 70012, IG 70016 and IG 70016), *C. judaicum* (IG 69980, IG 70032 and IG 70033), *C. pinnatifidum* (IG 69948) (Sharma *et al*., 2005a) and *C. reticulatum* (IG 70020, IG 72940, IG 72948 and IG 72949, and IG 72964) (Sharma *et al*., 2005b) showed resistance to *H. armigera*. With the use of interspecific hybridization, it would be possible to transfer resistance genes from the wild relatives to cultivated chickpea. Some of the wild relatives of chickpea may have different mechanisms of resistance than those in the cultivated types, which can be used in crop improvement to diversify the bases of resistance to this pest.

The development of crop cultivars that are resistant to, or tolerant of feeding damage has great potential in the regional management of *H. armigera (Hearn* and Fitt, 1988; Kennedy *et al.,* 1987). Many crops display characters that can be exploited by breeders to reduce attractiveness to ovipositing adults or suitability for larvae to feed (Kenedy *et al*, 1987; Thomson and Lee, 1980: Williams *at* al., 1980). The value of host-plant resistance (HPR) depends on the type of resistance, the behavior of the pest, and the diversity of the cropping system. To some extent the plant breeder has sought to redress the balance so as to exploit some of the natural defense mechanism which exist in nature (Maxwell and Jenning, 1980). These plant based defense mechanisms depend on the factors such as temporal avoidance, physical and chemical defense.

Host plant resistance through varietal resistance remains as the most effective tool in integrated pest management which is compatible with other methods of control with no additional cost to growers. Many workers like Singh and Sharma (1970); Lateef *et al.* (1981); Hafeez and Kotwal (1996); Patnaik and Mohapatra (1997) and Rashid *et al*. (2003) have screened a large number of chickpea genotypes for resistance/susceptibility to CPB. More than 14000 chickpea genotypes have been screened under pesticide free conditions against *H. armigera* at International Crops Research Institute for Semi Arid Tropics (ICRISAT), Hyderabad since 1976 (Romeis *et al*. 2004). Chickpea genotypes possessing low to intermediate resistance against CPB have been identified (Lateef and Sachin, 1990). Anwar and Shafique, (1993) tested 11 chickpea genotypes for resistance to *H. armigera*. Present study was therefore, carried out to screen 13 advanced desi chickpea genotypes for their resistance against CPB under natural field conditions.

2.10 Management

Gohokar et *al. (1985)* observed that the effectiveness of 6 insecticides against noctuid *Heliothis armigera* on gram *Cicer arietinum*. Applications of 0.01 and 0.02% fenvalerate, 0.006 and 0.009% cypermethrin, 0.002 and 0.004 decamethrin (deltamethrin), 0.04% monocrotophos, 5% neem [*Azadirachta indica*) seed extract and 0.07% endosulfan were sprayed at 50% flowering and 15 days later. Fenvalerate at a concentration of 0.01% was most effective in reducing the incidence of *H. armigera,* followed by 0.006% cypermethrin, monocrotophos, 0.004% deltamethrin, 0.009% cypermethrin,0.02% fenvalerate and 0.07% endosulfan which were equivalent ineffectiveness. The greatest yield was obtained from plots treated with 0.006%Cypermethrin, followed by 0.02% fenvalerate, 0.004% deltamethrin, 0.009% cypermethrin, neem seed extract and monocrotophos.

Thakur *et al., (1988)* carried out a field trial in Madhya Pradesh, India, in 1982 todetermine the effectiveness of a neem seed kernel extract, a neem leaf extract and some widely used insecticides against *Heliothis armigera [Helicoverpa* *armigera]*on gram [*Cicer arietinum*]. On the basis of grain yield, endosulfan at 0.07% was the most effective treatment, followed by monocrotophos at 0.04% and the neem leaf extract at 5%. It is concluded that the neem seed kernel extract can he used in place of the highly toxic synthetic insecticides because of its safety to beneficial insects and its lower cost peas. The growth index was greatest on chickpea, and it was concluded that this was the most suitable food plant pod damage and maximum grain yield.

Gupta *et al.* (1990) tested that the effectiveness of the insecticides monocrotophos, endosulfan, fenvalerate, decamethrin [deltamethrin] and cypermethrin and oils of neem *(Azadirachta indica)* and karanj [*Pongamia pinnata]* against *Heliothis armigera* [*Helicoverpa armigera]*on chickpea [*Cicer arietinum*] in the field in Madhya Pradesh, India. All treatments significantly reduced the larval population. The highest grain yield was obtained with 0.07% endosulfan, followed by 0.06% endosulfan and 0.04%monocrotophos. The most cost-effective treatment was 0.06% endosulfan, followed by 0.08% endosulfan and 0.001% deltamethrin.

Mehta *et al.*, (1991) carried out a field experiments in Himachal Pradesh, India, during 1986-89 with 8 insecticides in gram [chickpea) cv. C-235, cypermethrin at 0.004% was the most effective insecticide against *Heliothis armigera [H. armigera),* resulting in lowest.

Butani and Mittal (1993) tested neem seed kernel suspension and several conventional insecticides against gram pod borer. They observed that neem kernel is equally effective.

Butani and Mittal (1993) evaluated the efficacy of neem seed kernel suspension and several conventional insecticides against *Heliothis armigera [Helicoverpa armigera]* on gram [chickpeas) in Gujarat, India, during 1983-85. All the tested insecticides significantly reduced the pest population, with malathion, DDT and neem. Seed kernel suspension was equally effective. Grain yield was increased following treatment with phenthoate, fenitrothion, chlorpyrifos, DDVP (dichlorvos], carbaryl, DDT, malathion and neem seed kernel suspension.

Subbarayudu (1997) tested the efficacy of synthetic pyrethroids and conventional insecticide. He found the lowest percent of pod damage and maximum grain yield 0.0135%. Cypermethrin tested plot.

Chand *et al.,* (1999) reported that the role of nuclear polyhedrosis virus (NPV) for managing *Helicoverpa armigera* in chickpea cv. Shoba growing at Saravanampatti, Coimbatore district, during 1997-98. Treatments were applied 3 times at 7-10 day intervals in the evening to reduce the inactivation of the virus by ultraviolet radiation. The results showed that *Helicoverpa armigera* can be controlled successfully through the use of NPV. Grain yield was highest (1029.6 kg/ha) when NPV was applied with 5% crude sugar $4^{-}5\%$ starch, followed by 5% crude sugar + 15% chickpea seed extract (972.39 kg/ha).

Suganthy and Kumar (2000) tested the relative efficacy of various plant protection options against *Helicoverpa armigera* in chickpea. Integrated pest management (IPM) was found to be the best treatment in the management of *Helicoverpa armigera* larvae (37% reduction over untreated control) followed by endosulfan (33%), HNPV [nuclear polyhedrosis virus) (29%). neem 25%) and erecting bird perches (23%). IPM registered the lowest percentage of pod damage (9.4%), followed by endosulfan (10.2%), compared to 18.8% in the untreated control. The maximum yield of 11.7 qha^{-1} ha^{-1} was obtained with IPM, followed by spraying endosulfan (10.5 q ha^{-1}) compared to 7.4 q ha^{-1} in untreated control. He concluded that IPM was the best treatment in terms of the cost benefit ratio (1:6.3), followed by the endosulfan treatment (1:6.1). Bajpai and Schgal (2000) conducted that karanja oil and neem product can be good alternative method for controlling gram pod borer.

Sundararajan and Kumuthakalavalli (2001) observed on aqueous leaf extracts of *Gnidia glauca* and *Toddalia asiatica* they screened out of their anti-feedant activity against the sixth instar larvae of *Helicoverpa armigera* by applying the aqueous leaf extracts at various concentrations (0.2, 0.4, 0.6, 0.8 and 1.0%) on young tomato leaves. Over 50% larval mortality was observed athigher concentrations (0.8 and 1.0%) of the aqueous extracts. Among the two aqueous leaf extracts tested. *T. asiatica* showed a higher rate of mortality (86.1%) at 1.0% concentration. A reduction in the rate of food consumption and growth was observed in the larvae of *H. armigera* after 48 h of treatment with both aqueous extracts.

Suganthy*et et. al.,* (2002) a study on soil inhabiting and aboveground natural enemy fauna of the pod borer, *Helicoverpa armigera*, such as ichneumonids.

braconids, trichogrammatids, tachinids, ants, other *hymenopterans,* gryllids, and spiders, in a chickpea ecosystem was conducted in Patancheru, AndhraPradesh, India, during the 1998-99 post rainy season. Treatments included a control. 0.006% neem [*A. indica]* extracts, *Helicoverpa armigera* nuclear polyhedrosis virus (NANPV) at 250 LE/ha, 0.07% endosultan 35 EC, establishment of bird perches at 1 perch per plot, and a combination of these treatments (integrated pest management (IPM)). The treatments were applied *5* times at 15-20 day intervals at 21, 36, 54, 71 and 85 days after sowing (DAS). Bird perches were installed on 21 DAS until harvest in the IPM treatment. neem was given as first and fourth spray, HANPV as second and fifth spray and endosulfan as third spray. The overall effect of the 5 sprays revealed that endosulfan was found to affect ground dwelling natural enemies severely, resulting in 40% reduction in natural enemy population compared w with the control followed by neem spray with 8% reduction. In plots given the IPM treatment, the reduction was observed to be 7%. The activity of aboveground natural enemies was greater in December-January than in February. In general, endosulfan resulted in the highest percentage of natural enemy reduction (45%) over control. It is concluded that apart from chemical sprays. All other treatments were safe to the natural enemy fauna living in the chickpea ecosystem.

Hafeez (2003) reported that the effects of insecticides monocrotophos36 WC (0.04, 0.06 and 0.08%), endosulfan 35 EC (0.07, 0.1 and 0.13%), carbaryl WP (0.1, 0.2 and 0.3%), cypermethrin 25 EC (0.006, 0.0075 and 0.009%) and neem oil 0.15 EC (0.1. 0.2 and 0.3°:O) on *Helicoverpa armigera* chickpea cv. C 235 were investigated in Jammu, India. The insecticides were sprayed at pod formation and at 15 days after the first spray. All insecticide treatments were effective in controlling pest population and increasing yield. Cypermethrin was the most effective in controlling the pest population, followed by Monocrotophos and endosulfan. Carbaryl and neem oil were the least effective in controlling the pest population.

Singh *et al.,* (1985) observed that percentage pod damage due to *H. armigera* was much less in pigeonpea plot treated with Ethanolic extract neem seed kernel (2%). Sarode *et al.,* (1995) revealed that all the HNPV and NSKE combinations performed better than single sprays of each. The application of

HNPV 500 LE ha^{-1} + NSKE 6% recorded maximum larval reduction of 79.8 and 65.2% at 7 and 14 days after spraying, respectively. also recorded significantly the highest yield of (1770 kg ha^{-1}).Kumar and Prasad (2002) recorded the highest larval reduction (75.25 to 100 %) of *H. armigera* in chickpea plot treated with lufenuron + Profenophos @ 600 ml/ha at the time of 50% flowering /pod initiation.

Yadav *et al.,* (2004) Among various treatments, chickpea plots treated with Delfin WG @ 1 kg ha-1 recorded minimum number of *H. armigera* larvae followed by HaNPV, Achook, and endosulfan with significant increase in yield over control. Visalakshimi *et al*., (2005) reported that application of neem effectively reduced the oviposition of *H. armigera* throughout the crop period. Among various IPM components (neem 0.06%, HaNPV 250 L/ha, bird perches one/plot, endosulfan 0.07%), neem and HaNPV found as effective as endosulfan in the terms of reduction larval population and pod damage, further, endosulfan comparatively found toxic to natural enemies present in chickpea eco-system. Reddy et al., (2010) studied the efficacy of common insecticides viz., neem seed kernel extract (NSKE), HaNPV, Endosulfan were tested alone and in combination against gram pod borer, *H. armigera* in chickpea. Result showed that larval reduction was highest with NSKE 1.66% + HaNPV 250LE/ha + Endosulfan 0.023% followed by NSKE 1.66%+ Endosulfan 0.023%, NSKE 2.5% + HaNPV 250LE sprayed twice at 15 days interval, respectively. Prasad *et al.,* (2010) four different concentrations (0.1,0.125, 0.2 and 0.25ml x108spores/ml) were sprayed topically against most damaging 4th instar larvae of *H.armigera,* a dose dependent mortality was observed that went up to 76.7 percent with highest dose of 0.25ml x108 spores/ml. Dunett test revealed percent mortality significant at 1 and 5 percent level with different doses.

2.10.1 Cultural manipulation

A number of cultural practices such as time of sowing, spacing, fertilizer application, deep ploughing, intercultural and flooding have been reported to reduce the survival of and damage by *Helicoverpa* spp. (Lal *et al*., 1980, 1985; Reed *et al*., 1987; Murray and Zalucki, 1990; Shanower *et al*., 1998; Romeis *et al*., 2004). Intercropping or strip-cropping with marigold, sunflower, linseed, mustard and coriander can minimize the extent of damage to the main crop.

Strip-cropping also increases the efficiency of chemical control. Handpicking of large-sized larvae can also be practised to reduce *Helicoverpa* damage. However, the adoption of cultural practices depends on the crop husbandry practices in a particular agro-ecosystem. Rotations do not help manage these polyphagous and very mobile insects, although it has been noted that some crops (e.g. lucerne) are more attractive to the moths, and susceptible crops should not be planted too close to the main crop. Habitat diversification to enhance pest control has been attempted in Australia. An area-wide population management strategy has been implemented in regions of Queensland and New South Wales to contain the size of the local *H. armigera* population, and chickpea trap crops have played an important role in this strategy (Ferguson and Miles, 2002; Murray *et al*., 2005b). Chickpea trap crops are planted after the commercial crops to attract *H. armigera* as they emerge from winter diapauses

The emergence from diapause typically occurs when commercial chickpea has senesced, and before summer crops (sorghum, cotton and mung bean) are attractive to moths (October to November). However, moths are diverted to weeds for oviposition (including wheat, *Triticum aestivum*) when they grow above the chickpea crop canopy (Sequeira *et al*., 2001). Trap crops are managed in the same way as commercial crops, but destroyed by cultivation before larvae begin to pupate. The trap crops reduce the size of the local *H. armigera* population before it can infest summer crops and start to increase in size. As a result, the overall *H. armigera* pressure on summer crops is reduced, resulting in greater opportunity for the implementation of soft control options, reduced insecticide use and greater natural enemy activity.

2.10.2 Biological control

The importance of both biotic and abiotic factors on the seasonal abundance of *H. armigera* is poorly understood. Low activity of parasitoids has been reported from chickpea because of dense layer of trichomes and their acidic exudates (Jalali *et al*., 1988; Murray and Rynne, 1994; Romeis *et al*., 1999). The ichneumonid, *Campoletis chlorideae* (Uchida), is probably the most important larval parasitoid on *H. armigera* in chickpea in India. *Carcelia illota* (Curran), *Goniophthalmus halli* Mesnil and *Palexorista laxa* (Curran) have also been reported to parasitize up to 54% larvae on chickpea (Yadava *et al*., 1991; King, 1994; Romeis and Shanower, 1996), although Bhatnagar *et al*. (1983) recorded only 3% parasitism on chickpea. Predators such as *Chrysopa* spp., *Chrysoperla* spp., *Nabis* spp., *Geocoris* spp., *Orius* spp. and *Polistes* spp. are the most common in India. Provision of bird perches or planting of tall crops that serve as resting sites for insectivorous birds such as myna and drongo helps reduce the numbers of caterpillars. The use of microbial pathogens including *H. armigera* nuclear polyhedrosis virus (HaNPV), entomopathogenic fungi, Bt, nematodes and natural plant products such as neem, custard apple and karanj (*Pongamia*) kernel extracts have shown some potential to control *H. armigera* (Sharma, 2001). HaNPV has been reported to be a viable option to control *H. armigera* in chickpea (Rabindra and Jayaraj, 1988; Cowgill and Bhagwat, 1996; Butani *et al*., 1997; Ahmad *et al*., 1999; Cherry *et al*., 2000). Jaggery (0.5%), sucrose (0.5%), egg white (3%) and chickpea flour (1%) are effective in increasing the activity of HaNPV (Sonalkar *et al*., 1998). In Australia, the efficacy of HaNPV in chickpea has been increased by the addition of milk powder, and more recently the additive Aminofeed (Anonymous, 2005). Spraying Bt formulations in the evening results in better control than spraying at other times of the day (Mahapatro and Gupta, 1999). Entomopathogenic fungus, *Nomuraea rileyi* (106 spores per ml), results in 90–100% larval mortality, while *Beauveria bassiana* (2.68 × 107 spores per ml) resulted in 6% damage in chickpea compared to 16.3% damage in the untreated control plots (Saxena and Ahmad, 1997). In Australia, specific control of *H. armigera* and *H. punctigera* on chickpea is being achieved using the commercially available HaNPV, with an additive that increases the level of control. Bt formulations are also used as a spray to control *Helicoverpa*.

There is voluminous information on parasitism, and to a lesser extent on predation of insect pests on different food legumes. The egg parasitoids, *Trichogramma* spp. And *Telenomus* spp. destroy large numbers of eggs of *H. armigera* and *H. punctigera,* but their activity levels are too low in chickpea and pigeonpea because of trichome exudates. The ichneumonid, *Campoletis chlorideae* Uchida is probably the most important larval parasitoid of *H. armigera* on chickpea (Pawar *et al.,* 1986). Tachinids parasitize late-instar *H. armigera* larvae, but result in little reduction in larval density. Six species of parasitoids have been recorded from field collected *Helicoverpa* pupae (Fitt, 1989). Potential biocontrol agents for *B. pisorum* have been documented (Baker, 1990). The most common predators of insect pests of food legumes are *Chrysopa* spp., *Chrysoperla* spp., *Nabis* spp., *Geocoris* spp., *Orius* spp., *Polistes* spp., and species belonging to Pentatomidae, Reduviidae, Coccinellidae, Carabidae, Formicidae and Araneida (Romeis and Shanower, 1996).

2.10.3 Chemical control

Management of *Helicoverpa* in India and Australia in chickpea and other high value crops relies heavily on insecticides. There is substantial literature on the comparative efficacy of different insecticides against *Helicoverpa*. Endosulfan, cypermethrin, fenvalerate, thiodicarb, profenophos, spinosad and indoxacarb have been found to be effective for *H. armigera* control on chickpea in Australia (Murray *et al*., 2005a). Spray initiation at 50% flowering has been found to be most effective (Sharma, 2001). The appearance of insecticide resistance in *H. armigera,* but not in *H. punctigera* is considered to be related to the greater mobility of the later species (Maelzer and Zalucki, 1999, 2000). However, *H. armigera* populations in the northern Australia are largely resistant to pyrethroids, carbamates and organophosphates. Introduction of new chemistry, notably indoxacarb and spinosad, is being managed to minimize the development of resistance in *H. armigera* through a strategy that takes into account it use in all crops throughout the year (Murray *et al*., 2005). Consequently, the use of indoxacarb in chickpea is limited to one application with a cut-off date for application to ensure that one generation of *H. armigera* is not exposed to the product in any crop before the commencement of its use in summer crops (cotton and mung bean).

Control of *H. armigera* almost everywhere relies heavily on the use of chemical pesticides. In Pakistan, yields of cotton were increased significantly by the introduction of insecticides but the release of a high yielding variety led to a dramatic fall in production due to the viral disease in recent years. Increased and earlier indiscriminate use of organophosphates to control virus vector whitefly had a detrimental effect on the natural enemies of *H. armigera,* so this pest once a minor in status has also increased in importance. The number of spray applications has increased and local distributors are selling variety of generic products. Some of these products are too toxic to be applied through manually operated sprays. In chemical control of *H. armigera*, in recent years, authorities has started utilizing electronic media to advice farmers, who in the past without any adequate training, have misused chemicals while attempting to maximize their income in the short term. The big plunge in the production of cotton in *Pakistan* as compared to other cotton growing countries *has* encouraged efforts to introduce integrated pest management, but adoption in many of these areas has been difficult and slow due to the scale of the problem and lack of cooperation between organizations and personnel (Karim *et al*., 2000).

A wide variety of insecticides have been used to control *H. armigera*, and in many areas, several applications are needed to contain this pest (Reed *et al.*, 1987). Intensive insecticide application to control *H. armigera* on various crops (especially cotton) has resulted in the development of resistance to the major classes of insecticides such as chlorinated hydrocarbons, organophosphates, synthetic pyrethroids and carbamates (Armes *et al.*, 1996).

CHAPTER III

METERIELS AND METHODS

This chapter deals with the materials and methods those were used in conducting the experiment. It consists of a short description of location of' the experimental plot, characteristics of soil, climate, material used, treatments, layout and design of experiment, land preparation , sowing and gap filling, after cares, harvesting, and collection of data. These are described below:

3.1 Location of the experimental plot

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2012 to February 2013.

Plate 1: Experimental plot in the farm of Sher-e-Bangla Agricultural University

3.2 Soil

The soil was silty clay in texture having 26% sand, 45% silt and 29% clay and the pH was 5.6. The physio-chemical properties of the soil are presented in Appendix I. The experimental site belongs to the Madhupur Tract Agro Ecological Zone (AEZ-28). The experimental site was a medium high land.

3.3 Climate

The climate of experimental site was under the sub-tropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979).There was no rainfall during the month of November and December, little rain in January and February. The average maximum temperature during the period of experiment was33.8°C and the average minimum temperature was 13°C. Details of the meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka.

3.4 Seeds used for experiment

Seeds of gram variety BARI Chola-5 were used as a test crop for the study and the seeds of this variety were collected from Bangladesh Agricultural Research Institute, Gazipur. This variety was developed by BARI and exposed for cultivation in the year of 1996 (BARI, 2006) through the selection process among the different germ plasms that generally has been cultivated in different areas of Bangladesh. It is a spreading type plant and can be easily grown in minimum or shading light.

3.5 Experimental Design and layout

The experiment was conducted considering eight treatments and laid out in a Randomized Complete Block Design (RCBD). Each treatment was allocated randomly in three replications. The unit plot size was 2 m ×2.5 m having 1 m space between the blocks and 0.75 m between the plots. Each plot contains two rows having 60cm distance between the row and that between plants was 30 cm.

3.6 Land preparation and fertilization

The plot selected for the experiment was opened in the first week of November 2012 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Each ploughing was followed by laddering to have a desirable fine tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for sowing. During land preparation 10 t/ha decomposed cow dung were mixed with soil and following fertilizers were applied. Urea, TSP, MP and Boric acid as the source of Nitrogen (N), Phosphorus (P_2O_5), Potassium (K_2O) and Boron (B) fertilizers were applied @ Urea 50 kg/ha, TSP 85 kg/ha, MP 40 kg/ha and Boric acid 10 kg/ha.

3.7 Treatments of the experiment

There were eight treatments combinations will be tested in this experiment.

T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals.

T_2= Garlic Extract @ 100 g/L of water at 7 days intervals.

T_3= Neem oil @ 3 ml/L of water at 7 days intervals.

T_4= Chilli Extract @ 10 g/L of water at 7 days intervals.

T_5= Ripcord @ 2 ml/L of water at 7 days intervals.

T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals.

T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals.

T_8 = Untreated control

3.8 Seed processing and treatment

The seeds of BARI chola-5 of Chickpea were collected from Bangladesh Agricultural Research Institute, Gazipur. Germination test was done before sowing. The rate of germination was found more than 95%. The seeds were treated with Vitavax 200 at the rate of 2 g per kg seed to protect seedlings against foot and root rot diseases.

3.10 Sowing of seeds

The seeds of Chick pea were sown in different plots of the experimental field on 20 November 2012 in rows with spacing of 60 cm × 30 cm.

3.11 Intercultural operations

Intercultural operations like thinning, weeding and mulching were done as and when necessary for proper growth and development of the crop.

3.11.1 Irrigation

Four irrigations were given throughout the growing period. The first irrigation was given at 7 days after sowing for well growth and development of chickpea plant followed by irrigation 15 days after the first irrigation and the other was done in the same way. Mulching was also done by breaking the soil crust after irrigation properly.

3.12 Harvesting

Harvesting was done when 90% of the seed became dark brown in color. The matured crops were harvested and tied under plot wise. The pods were then dried in bright sunshine. The yield obtained from each plot was converted into yield per hectare.

Plate 2. Infested pod with hole at experimental field

Plate 3. Infested plant & pod at the experimental field

Plate 4: Pod borer larva on chickpea plant

Plate 5: A pod borer larva

3.13 Data collection

The data was collected at 7 days interval from the field and recorded on the basis of treatments and replications. The data collection was started at the flower initiation stage of the chickpea plant in the field and continued upto maturity of the pods and after harvest of the crops. The data were collected on different parameters of the study such as number of total pod per five selected plants/plot; number of borer infested pods /5 selected plant/plot; total number of plants/plot; total number of infested plants/plot; total yield / plot; yield of borer infested pod/5 selected plants; no. of larvae / 10 infested pods (at harvest); no. of borers/ 20 infested pods; no. of grain / 20 pods (at harvest); no. of pods / 5 selected plant; no. of seeds / 5 selected plant; weight of 5 selected plants pod; 1000 seed weight; yield of chickpea per plot.

3.14 Calculation of the recorded data

The data recorded on different parameters were calculated using the following formula:

$$\text{\% pod infestation} = \frac{\text{No. of infested pod}}{\text{Total no. of pod}} \times 100$$

% increase or decrease over control

$$= \frac{\text{Mean value of treated plot–Mean value of untreated plot}}{\text{Mean value of untreated plot}} \times 100$$

3.14 Statistical analysis

The collected data on different parameters were statistically analyzed to obtain the level of significance using the MSTAT-C computer package program developed by Russell (1986). The mean differences among the treatments were adjusted by using Least Significant Difference (LSD) test for significance.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the explanation and presentation of the results obtained from the experiment on eco-friendly management of chickpea pod borer *Helicoverpa armigera* (Hubner) using chemical insecticides and botanicals. The data have been presented and discussed and possible interpretations are made under the following sub headings:

4.1 Effect of management practices on the pod infestation by chickpea pod borer

From the results in Table 1 showed significant variation due to the effect of different management practices on the incidence of percent of reduction of chickpea pod borer at different days after sowing (DAS). The highest (2.27%) percent pod infestation was found in T_7 treatment followed by all treatment with no significance different after 90 DAS. Although % pod infestation was highest (2.40%) in T_8 untreated control plot followed by T_4 (2.07%), T_2 (2.27%) and T_7 (2.07%) treatments has no significance difference and the lowest % pod infestation was found in T_3 treatment followed by T_1 (1.53%), T_5 (1.53%) and T_6 (1.33%) treatment has no significance difference after 97 DAS. However, % pod infestation was highest (2.67%) in T_8 untreated control plot and lowest % pod infestation was found in T_3 (1.07%) treatment after 104 DAS. The highest (2.40%) mean percent pod infestation was found in T_8 untreated control plot followed by T_2 (2.20%), T_4 (2.13%) and T_7 (2.04%) respectively has no significant difference. The lowest (1.47%) percent infestation was found in T_3 treated plot followed by T_1 (1.60%), T_5 (1.67%) and T_7 (2.04%) respectively has no significant difference among different treatment.

In terms of percent pod infestation reduction over control all treatment reduced considerable amount of pod damage over control as shown in the Table-1. The highest percent reduction of pod infestation (38.80%) was recorded in T_3 treated plots followed by T_6 (36.86%), T_1 (33.24%), T_5 (30.32%), T_7 (24.75%), T_4 (10.99%) and T_2 (8.21%) treated plots, respectively during cropping season.

Table-1: Percent pod infestation throughout the growing period of chickpea

Treatment	% Pod infestation				
	90 DAS*	97 DAS	104 DAS	Mean	% reduction over control
T_1	1.87 a	1.53 bc	1.40 cd	1.60 bcd	33.24
T_2	1.93 a	2.27 a	2.40 ab	2.20 ab	8.21
T_3	2.07 a	1.27 c	1.07 d	1.47 d	38.80
T_4	1.80 a	2.07 ab	2.53 ab	2.13 abc	10.99
T_5	1.60 a	1.53 bc	1.87 bc	1.67 bcd	30.32
T_6	1.73 a	1.33 c	1.47 cd	1.51 cd	36.86
T_7	2.27 a	2.07 ab	1.80 bcd	2.04 abcd	14.75
T_8	2.13 a	2.40 a	2.67 a	2.40 a	-
$LSD_{(0.05)}$	0.77	0.72	0.79	0.63	-
CV (%)	22.77	22.58	23.64	19.09	-

* DAS= Days after sowing

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

[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

From the above findings it was revealed that neem oil @ 3 ml/L of water at 7 days intervals performed as the best treatment (38.80%) in decreasing pod infestation during the management of chickpea pod borer followed by Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals (36.86%), Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (33.24%) and Ripcord @ 2 ml/L of water at 7 days intervals (30.32%). As a result, the trend of results in terms of decreasing the percent pod infestation is $T_3>T_6>T_1>T_5>T_7>T_4>T_2$.

4.2 Effect of management practices on the incidence of larvae on pods

The comparative effectiveness of various treatments on larvae number per ten infested pod has been evaluated as well as in percent (%) reduction of larvae number over control is presented in Table 2. The data indicated that the highest (1.72/10 infested pod) number of larvae was found in T_8 untreated control plot which was significantly different among all treatments after 90 DAS. Although the highest (1.63/10 infested pod) number of larvae was found in T_8 untreated control plot which has no significant different among all treatments after 97 DAS. But after 104 DAS the lowest no of larvae was found in both T_3 and T_2 (1.46/10 infested pod) treatments and the highest (1.69/10 infested pod) number of larvae was found in T_8 untreated control plot. The highest (1.85/10 infested pod) mean number of larvae was found in T_8 untreated control plot which was significantly different among all treatments. The lowest (1.07/10 infested pod) number of larvae was obtained in T_3 treated control plot followed by T_1, T_5, T_6 and T_7 respectively having no significant difference.

In terms of percent number of larvae reduction over control, all treatment reduced considerable number of pod damage over control as shown in the Table-2. The highest (42.02%) percent reduction of number of larvae was recorded in T_3 treated plots followed by T_6 (34.02%), T_5 (32.00%), T_7 (32.00%), T_1 (28.01%), T_4 (22.01%) and T_2 (21.99%) treated plots, respectively during cropping season.

Table-2: Incidence of larvae on pods throughout the pod development stage of chickpea

Treatment	Incidence of larvae (No./10 infested pod)				
	90 DAS*	97 DAS	104 DAS	Mean	% reduction over control
T_1	1.47 a	1.29 a	1.48 bc	1.33 bc	28.01
T_2	1.49 a	1.31 a	1.46 c	1.44 b	21.99
T_3	1.48 a	1.33 a	1.46 c	1.07 c	42.01
T_4	1.50 a	1.36 a	1.48 bc	1.44 b	22.01
T_5	1.49 a	1.32 a	1.57 abc	1.26 bc	32.00
T_6	1.51 a	1.31 a	1.61 abc	1.22 bc	34.02
T_7	1.52 a	1.40 a	1.65 ab	1.26 bc	32.00
T_8	1.72 b	1.63 a	1.69 a	1.85 a	-
$LSD_{(0.05)}$	0.77	0.71	0.79	0.63	-
CV (%)	5.14	16.57	6.48	14.88	-

* DAS= Days after sowing
In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).
[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

From the above findings it was revealed that Neem oil @ 3 ml/L of water at 7 days intervals performed as the best treatment (42.01%) in decreasing number of larvae during the management of chickpea pod borer followed by Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals (34.02%), Ripcord @ 2 ml/L of water at 7 days intervals (32.02%) and Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (33.24%) and Ripcord @ 2 ml/L of water at 7 days intervals (30.32%).

As a result, the trend of results in terms of decreasing the percent pod infestation is T_3>T_6>T_1>T_5>T_7>T_4>T_2.

4.3 Effect of management practices on the incidence of bore on pods

The comparative effectiveness of various treatments on bore number per ten infested pod has been evaluated as well as in percent (%) reduction of bore number over control is presented in Table 3. The data indicated that there is no significant difference was found in both 90 and 97 DAS among all treatments. Although the highest (12.00/10 infested pod) number of bore was found in T_8 untreated control plot and the lowest (10.00/10 infested pod) number of bore was found in T_2 treatment after 104 DAS. But the highest (12.11/10 infested pod) mean number of bore was found in T_8 untreated control plot and which differed significantly from other treatments. The lowest (10.89/10 infested pod) number of bore was obtained in T_2 treated control plot followed by all treatment except untreated control plot having no significant difference.

Table -3: Incidence of bore on pods throughout the pod developing period of chickpea

Treatment	No. of bore per ten infested pod				
	90 DAS*	97 DAS	104 DAS	Mean	% reduction over control
T_1	11.67 a	10.67 a	11.00 ab	11.11 b	8.26
T_2	11.33 a	11.33 a	10.00 b	10.89 b	10.09
T_3	10.33 a	11.67 a	11.00 ab	11.00 b	9.17
T_4	11.67 a	11.00 a	11.33 ab	11.33 b	6.42
T_5	10.33 a	12.33 a	11.67 a	11.44 b	5.51
T_6	11.67 a	11.00 a	11.67 a	11.44 b	5.51
T_7	11.33 a	12.00 a	10.67 ab	11.33 b	6.42
T_8	12.33 a	12.00 a	12.00 a	12.11 a	-
$LSD_{(0.05)}$	0.77	0.71	0.79	0.63	-
CV (%)	11.85	13.03	7.01	3.25	-

* DAS= Days after sowing

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

[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

In terms of percent number of bore reduction over control, all treatment reduced considerable amount of pod damage over control as shown in the Table-3. The highest (10.09%) percent reduction of number of bores was recorded in T_2 treated plots followed by T_3 (9.17%), T_1 (8.26%), T_7 (6.42%), T_4 (6.42%), T_5 (5.51%) and T_6 (5.51%) treated plots, respectively during cropping season.

From the above findings it was revealed that Garlic Extract @ 100 g/L of water at 7 days intervals performed as the best treatment (10.09%) in decreasing number of bore during the management of chickpea pod borer followed by Neem oil @ 3 ml/L of water at 7 days intervals (9.17%) and Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (8.26%). As a result, the trend of results in terms of decreasing the percent bore number is $T_2>T_3>T_1>T_4=T_7>T_5=T_6$.

4.4 Effect of management practices on production of pod per plant

The comparative effectiveness of various treatments on number of pod per plant has been shown in Table-4. The data indicated that the highest number of pod per plant (53.27/plant) was observed in T_3 treated plot followed by T_1 (51.67/plant), T_5 (48.00/plant), T_6 (46.93/plant) and T_7 (46.27/plant) treated plots, respectively having no significant difference among them. On the other hand lowest number of pod per plant was observed in T_8 (38.80/plant) untreated plot followed by T_4 (43.00/plant) and T_2 (40.60/plant) treated plots, respectively having no significant difference among them.

In terms of percent increase of number of pod per plant over control, all treatments increased considerable amount of pod number over control as shown in the Table-4. The highest (37.29%) percent increase of number of pod was recorded in T_3 treated plots followed by T_1 (33.16%), T_5 (23.71%), T_6 (20.96%), T_7 (19.24%), T_4 (10.82%) and T_2 (4.64%) treated plots, respectively during cropping season.

From the above findings it was revealed that Neem oil @ 3ml/L of water at 7 days intervals performed as the best treatment (37.29%) in increasing number of pod during the management of chickpea pod borer followed by Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (33.16%) and Ripcord @ 2 ml/L of water at 7 days intervals (23.71%). As a result, the trend of results in terms of increasing the percent pod number is $T_3>T_1>T_5>T_6>T_7>T_4>T_2$.

Table- 4: Number of pod per plant at harvest

Treatment	No of Pod/Plant	% increase over control
T_1	51.67 a	33.16
T_2	40.60 cd	4.64
T_3	53.27 a	37.29
T_4	43.00 bcd	10.82
T_5	48.00 ab	23.71
T_6	46.93 abc	20.96
T_7	46.27 abc	19.24
T_8	38.80 d	-
$LSD_{(0.05)}$	7.11	-
CV (%)	8.81	-

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).
[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

4.5 Effect of management practices on number of seeds per plant at harvest

The comparative effectiveness of various treatments on number of seeds per plant at harvest has been evaluated as in percent (%) increase on number of seeds per plant over control is presented in Table 5. The data indicated that highest (58.73/plant) number of seeds per plant was obtained in T_3 treated plot followed by T_1 (57.53/plant), T_5 (53.53/plant), T_6 (51.53/plant) and T_7 (50.80/plant) treated plots, respectively having no significant difference among them. On the other hand lowest number of seeds per plant (43.40/plant) was recorded in T_8 untreated control plot followed by T_2 (45.73/plant), T_4 (47.53/plant), T_6 (51.53/plant) and T_7 (50.80/plant) treated plots, respectively having no significant different among them.

In terms of percent increase of number of seeds per plant over control, all treatments increased considerable amount of seed number over control as shown in the Table-5. The highest (35.33%) percent increase of number of seed was recorded in T_3 treated plots followed by T_1 (32.56%), T_5 (23.35%), T_6 (18.74%), T_7 (17.05%), T_4 (9.52%) and T_2 (5.38%) treated plots, respectively during cropping season.

From the above findings it was revealed that Neem oil @ 3 ml/L of water at 7 days intervals performed as the best treatment (37.29%) in increasing number of pod during the management of chickpea pod borer followed by Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (33.16%) and Ripcord @ 2 ml/L of water at 7 days intervals (23.71%). As a result, the trend of results in terms of increasing the percent pod number is $T_3>T_1>T_5>T_6>T_7>T_4>T_2$.

Table 5: Number of seeds per plant under different treatments at harvest

Treatment	No. of seeds/plant	% increase over control
T_1	57.53 a	32.56
T_2	45.73 bc	5.38
T_3	58.73 a	35.33
T_4	47.53 bc	9.52
T_5	53.53 ab	23.35
T_6	51.53 abc	18.74
T_7	50.80 abc	17.05
T_8	43.40 c	-
$LSD_{(0.05)}$	8.75	-
CV (%)	9.77	-

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

[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

4.6 Effect of management practices on grain production

The comparative effectiveness of various treatments on grain weight per plant has been evaluated as well as percent (%) increase over control is presented in Table 6. The data indicated that highest (10.47/plant) grain weight per plant was recorded in T_1 treated plot followed by T_3 (9.93/plant), T_5 (9.27/plant) and T_6 (9.07/plant) treated plots, respectively having no significant difference among them. On the other hand lowest grain weight per plant (6.40/plant) was recorded in T_8 untreated control plot followed by T_2 (7.13/plant), T_7 (8.00/plant) and T_4 (7.07/plant) treated plots, respectively having no significant different among them.

In terms of percent increase of grain weight per plant over control, all treatments increased considerable amount of grain weight over control as shown in the Table-6. The highest (63.55%) percent increase of grain weight was recorded in T_1 treated plots followed by T_3 (55.20%), T_5 (40.80%), T_6 (41.67%), T_7 (25.00%), T_2 (11.45%) and T_4 (10.42%) treated plots, respectively during cropping season.

Table 6: Chickpea grain weight per plant under different treatments at harvest

Treatment	Grain weight (g/plant)	% increase over control
T_1	10.47 a	63.55
T_2	7.13 cde	11.45
T_3	9.93 ab	55.20
T_4	7.07 de	10.42
T_5	9.27 abc	44.80
T_6	9.07 abcd	41.67
T_7	8.00 bcde	25.00
T_8	6.40 e	-
$LSD_{(0.05)}$	2.18	-
CV (%)	14.80	-

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

[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

From the above findings it was revealed that Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals performed as the best treatment (63.55%) in increasing grain weight during the management of chickpea pod borer followed by Neem oil @ 3 ml/L of water at 7 days intervals (55.20%), Ripcord @ 2 ml/L of water at 7 days intervals (44.80%) and Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals (41.67%). As a result, the trend of results in terms of increasing the percent grain weight is $T_1>T_3>T_5>T_6>T_7>T_2>T_4$.

4.7 Effect of management practices on thousand grain weight

The comparative effectiveness of various treatments on thousand grain weight (g) has been evaluated as well as percent (%) increase over control is presented in Table 7. The data indicated that the highest (0.1383) weight of 1000 grain was obtained in T_3 treated plot followed by T_1 (0.1377), T_5 (0.1343) and T_6 (0.1343) treated plots, respectively having no significant difference among them. On the other hand the lowest (0.1197) weight of 1000 grain was obtained in T_8 untreated control plot which has significant difference among all treatment.

In terms of percent increase of thousand grain weight over control, all treatments increased considerable amount of thousand grain weight over control as shown in the Table-7. The highest (15.54%) percent increase of thousand grain weight was recorded in T_3 treated plots followed by T_1 (15.04%), T_5 (12.20%), T_6 (12.20%), T_7 (7.18%), T_4 (6.35%) and T_2 (5.51%) treated plots, respectively during cropping season.

Table 7: Thousand seed weight of chickpea under different treatments at harvest

Treatment	1000 seed weight (g)	% increase over control
T_1	0.1377 a	15.04
T_2	0.1263 b	5.51
T_3	0.1383 a	15.54
T_4	0.1273 b	6.35
T_5	0.1343 a	12.20
T_6	0.1343 a	12.20
T_7	0.1283 b	7.18
T_8	0.1197 c	-
$LSD_{(0.05)}$	0.00529	-
CV (%)	2.31	-

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

[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

From the above findings it was revealed that Neem oil @ 3 ml/L of water at 7 days intervals performed as the best treatment (15.54%) in increasing thousand grain weight during the management of chickpea pod borer followed by Neem Seed Kernel

Extract @ 100 g/L of water at 7 days intervals (15.04%), Ripcord @ 2 ml/L of water at 7 days intervals (12.20%) and Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals (12.20%). As a result, the trend of results in terms of increasing the percent thousand grain weight is $T_3>T_1>T_5=T_6>T_7>T_4>T_2$.

4.8 Effectiveness on yield of chickpea under different treatments

The comparative effectiveness of various treatments on yield of chickpea has been evaluated as well as percent (%) increase over control is presented in Table 8.The data indicated that highest (1.10 ton/ha) yield was obtained in T_3 treatment plot followed by T_1 (1.03 ton/ha) and T_7 (1.02 ton/ha) treated plots, respectively having no significance difference. However, the lowest (0.80 ton/ha) yield was obtained in T_8 untreated control plot followed by T_4 (0.88 ton/ha) and T_2 (0.89 ton/ha) treated plot having no significant difference.

Table 8: Yield of chickpea under different treatments during Rabi season

Treatment	Yield (g/plot)	% increase over control	Yield (ton/ha)	% increase over control
T_1	516.00 ab	28.78	1.03 ab	28.79
T_2	444.00 cde	10.81	0.89 cde	10.82
T_3	551.67 a	37.69	1.10 a	37.69
T_4	438.67 de	9.48	0.88 de	9.48
T_5	494.33 bc	23.38	0.99 bc	23.39
T_6	482.00 bcd	20.30	0.96 bcd	20.30
T_7	511.00 ab	27.54	1.02 ab	27.54
T_8	400.67 e	-	0.80 e	-
$LSD_{(0.05)}$	53.67	-	0.11	-
CV (%)	6.39	-	6.39	-

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

[T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control]

In terms of percent increase of yield over control, all treatments increased considerable amount of yield over control as shown in the Table-8. The highest (37.69%) percent increase of yield was recorded in T_3 treated plots followed by T_1

(28.79%), T_7 (27.54%), T_5 (23.39%), T_6 (20.30%), T_2 (10.82%) and T_4 (9.48%) treated plots, respectively during cropping season.

From the above findings it was revealed that Neem oil @ 3 ml/L of water at 7 days intervals performed as the best treatment (37.69%) in increasing yield during the management of chickpea pod borer followed by Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (28.78%), Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals (27.54%). As a result, the trend of results in terms of increasing the percent yield is $T_3>T_1>T_7>T_5>T_6>T_2>T_4$.

4.9 Relationship between pod infestation and grain weight of chickpea

Correlation study was done to establish a relationship between % pod infestation and grain weight. From the study it was revealed that significant correlation existed between the characters (Figure-1). The regression equation y= -1.055x +10.23 gave a good fit to the data and value of the co-efficient of determination (R^2 = 0.399). From this it can be concluded that the grain weight per plant was decreased with the increase of number of infestation.

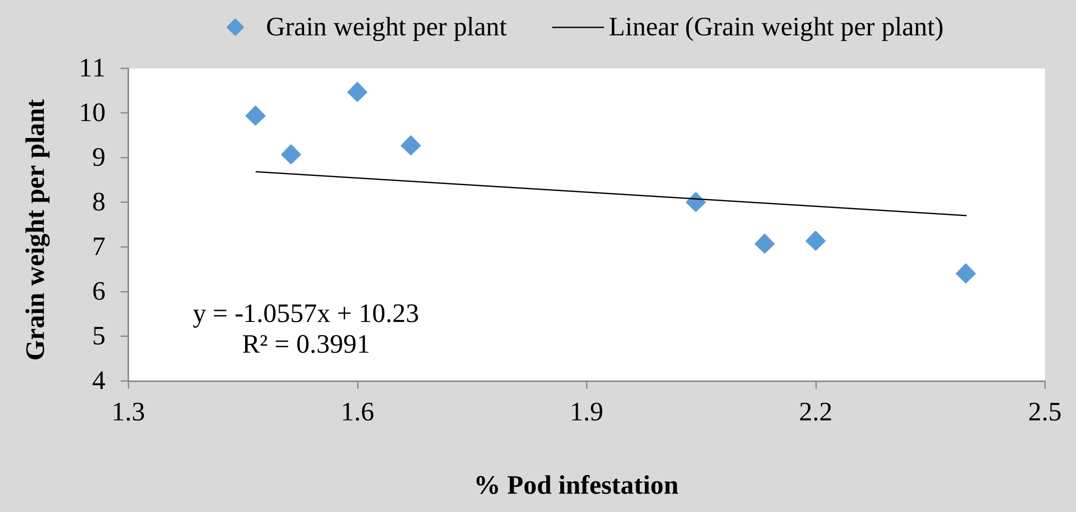

Figure-1: Relationship between percent pod infestation and grain weight per plant

4.10 Relationship between pod infestation and thousand grain weight of chickpea

Correlation study was done to established a relationship between % pod infestation and thousand grain weight. From the study it was revealed that significant correlation existed between the characters (Figure-2). The regression equation y= -0.000x +0.13 gave a good fit to the data and value of the co-efficient of determination ($R^{2\,=}$ 0.01).

From this it can be concluded that the thousand grain weight per plant was decreased with the increase of number of infestation.

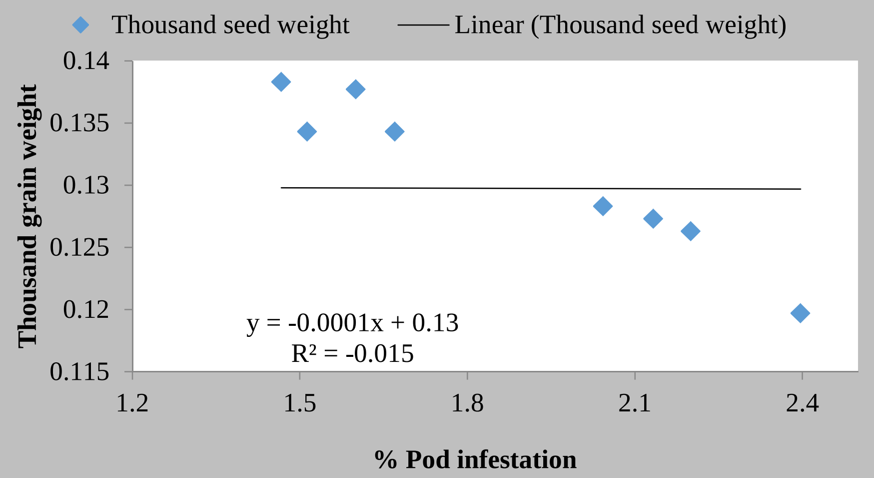

Figure-2: Relationship between percent pod infestation and thousand seed weight

4.11 Relationship between pod infestation and yield (ton/ha)

Correlation study was done to established a relationship between % pod infestation and yield (ton/ha). From the study it was revealed that significant correlation existed between the characters (Figure-3). The regression equation y= -0.069x +1.08 gave a good fit to the data and value of the co-efficient of determination (R^2 = 0.341). From this relations it can be concluded that the yield was decreased with the increase of number of infestation.

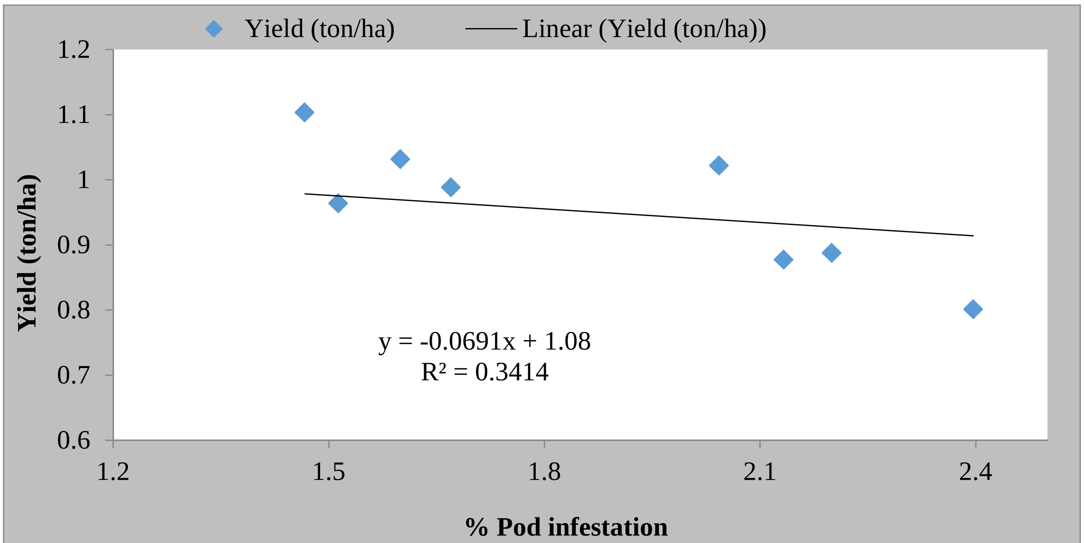

Figure-3: Relationship between pod infestation and yield

CHAPTER V
SUMMARY AND CONCLUSION

Eco-friendly management of chickpea pod borer (*Helicoverpa armigera* Hubner) was investigated at the field of the Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2012 to February 2013. The treatments are comprised with both botanicals and insecticides. These are T_1= Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals, T_2= Garlic Extract @ 100 g/L of water at 7 days intervals, T_3= Neem oil @ 3 ml/L of water at 7 days intervals, T_4= Chilli Extract @ 10 g/L of water at 7 days intervals, T_5= Ripcord @ 2 ml/L of water at 7 days intervals, T_6 = Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals, T_7 = Quinalphos (Corollax 25EC) @ 1.5 ml/L of water at 7 days intervals and T_8 = Control. The experiment was laid out in single factor Randomized Complete Block Design (RCBD) with three replications.

In terms of percent reduction of pod infestation during the management of chickpea pod borer, treatment T_3 comprising spraying of Neem oil @ 3 ml/L of water at 7 days intervals performed as the best treatment (38.80%) in reducing pod infestation during the management of chickpea pod borer followed by Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals (36.86%) and Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (33.24%) whereas T_2 showed least performance (8.21%) Spraying of Garlic Extract @ 100 g/L of water at 7 days intervals in reducing pod infestation by number over control. As a result, the trend of results in terms of decreasing the percent pod infestation is $T_3>T_6>T_1>T_5>T_7>T_4>T_2$.

In terms of larvae number, the lowest (1.07) number of larvae was found in Neem oil @ 3 ml/L of water at 7 days intervals treated plot followed by Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals (1.33), Dimethoate (Toughgor 40EC) @ 2 ml/L of water at 7 days intervals (1.22), Ripcord @ 2 ml/L of water at 7 days intervals (1.26) showing least difference. Similarly the best treatment (42.01%) in reducing percent larvae number is T_3 (Neem oil @ 3 ml/L of water at 7 days intervals) treated plot whereas the least performance (21.00%) was observed in T_2 (Garlic Extract @ 100 g/L of water at 7 days intervals) treated plot. As a result, the trend of results in terms of decreasing the percent pod infestation is $T_3>T_6>T_1>T_5>T_7>T_4>T_2$.

In terms of bore number, there is only significant difference observed between control plot and other treatments. Although the best performance (10.89) was observed in T_2 (Garlic Extract @ 100 g/L of water at 7 days intervals) treated plot followed by all treatment except untreated control plot whereas lowest incidence of bore number was observed in T_8 (Control) untreated plot. As a result, the trend of results in terms of decreasing the percent bore number is $T_2>T_3>T_1>T_4=T_7>T_5=T_6$.

The highest number of pod was (53.27/plant) observed in T_3 treated plot followed by 51.67, 48.00, 46.93 and 46.27 per plant in T_1, T_5, T_6 and T_7 treated plots respectively having no significant difference among them. Whereas the lowest number of pod per plant (38.80/plant) was recorded in control plot which was statistically different from all other treatments and it was followed by T_2 (40.60/plant), and T_4 (43.00/ plant) treated plots. In term of percent increase of pod number, T_3 (Neem oil @ 3 ml/L of water at 7 days intervals) treated plot shows the best (37.29%) result whereas lowest (4.64%) percent increase was recorded in T_2 (Garlic Extract @ 100 g/L of water at 7 days intervals) treated plot. As a result, the trend of results in terms of increasing the percent pod number is $T_3>T_1>T_5>T_6>T_7>T_4>T_2$.

In terms of percent increase of number of seeds per plant over control, all treatments increased considerable amount of seed number over control. The best performance (35.33%) percent increase of number of seed was recorded in T_3 (Neem oil @ 3 ml/L of water at 7 days intervals) treated plot followed by 32.56%, 23.35%, 18.74% and 17.05% in T_1, T_5, T_6, and T_7 treated plots, respectively whereas the lowest (5.38%) percent increase of seed number was found in T_2 (Garlic Extract @ 100 g/L of water at 7 days intervals) treated plot. As a result, the trend of results in terms of increasing the percent pod number is $T_3>T_1>T_5>T_6>T_7>T_4>T_2$.

In terms of grain weight per plant, best performance (10.47/plant) shows in T_1 (Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals) treated plot. Whereas lowest (8.00/plant) result found in T_8 untreated control plot. In terms of percent increase of grain weight per plant over control, all treatments increased considerable amount of grain weight over control. The highest (63.55%) percent increase of grain weight was recorded in T_1 treated plots followed by 55.20% in T_3 (Neem oil @ 3 ml/L of water at 7 days intervals) treated plot whereas lowest percent (10.42/plant) increase was recorded in T_4 (Chilli Extract @ 10 g/L of water at 7 days intervals) treated plot. As a result, the trend of results in terms of increasing the percent grain weight is $T_1>T_3>T_5>T_6>T_7>T_2>T_4$. In terms percent increase of thousand grain weight, best (15.54%) performance was recorded in Neem oil @ 3 ml/L of water at 7 days intervals treated plot followed by 15.04% in T_1 (Neem Seed Kernel Extract @ 100 g/L of water at 7 days intervals) treated plot with least difference whereas lowest (5.51%) percent increase was recorded in Garlic Extract @ 100 g/L of water at 7 days intervals treated plot. As a result, the trend of results in terms of increasing the percent thousand grain weight is $T_3>T_1>T_5=T_6>T_7>T_4>T_2$.

In terms of yield of chickpea, highest (1.10 ton/ha) yield (ton/ha) was recorded in T_3 (Neem oil @ 3 ml/L of water at 7 days intervals) treated plot whereas lowest (0.80 ton/ha) yield was recorded in untreated control plot. The highest (37.39%) percent increase of yield was recorded in T_3 (Neem oil @ 3 ml/L of water at 7 days intervals) treated plot followed by 28.79% and 27.54% respectively in T_1 and T_7 treated plot respectively over control. On the other hand, lowest (9.48%) percent increase was recorded in Chilli Extract @ 10 g/L of water at 7 days intervals treated plot. As a result, the trend of results in terms of increasing the percent yield is $T_3>T_1>T_7>T_5>T_6>T_2>T_4$.

CONCLUSION

- Based on the above findings of the study it can be concluded that recommended dose of Neem oil (3 ml/L) was found on the effective treatment for the management of Chickpea pod borer (*Helicoverpa armigera* Hubner).
- Neem oil (3ml/L) also increased pod number, seed number, thousand grain weight and yield.
- It also reduced percent pod infestation and larvae number. Only grain weight was increased in recommended dose of Neem Seed Kernel Extract (100g/L).

RECOMMENDATIONS

Considering the findings of the study the following recommendations can be drawn:

1. The neem oil @ 3 ml/L of water may be suggested for eco-friendly management of chickpea pod borer.
2. Further study can be conducted with different doses of other botanicals.
3. Further intensive studies based on different botanical management practice should be done.

CHAPTER VI

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