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EFFECT OF DATES OF SOWING ON THE INCIDENCE OF CHICKPEA POD BORER IN FIELD AND PULSE BEETLE IN STORAGE

BY

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CERTIFICATE

This is to certify that thesis entitled, **"Effect of dates of Sowing on the Incidence of Chickpea Pod Borer in Field and Pulse Beetle in Storage"** 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 in ENTOMOLOGY,** embodies the result of a piece of bona fide research work carried out by **Zobiada Rukshanara**, **Registration No. 03-01126** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2008
Place: Dhaka, Bangladesh

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Dedicated TO
MY
Beloved Parents

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ABSTRACT

The study was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November, 2007 to February, 2008 to find out the effect of dates of sowing on the incidence of chickpea pod borer in field and pulse beetle in storage. The experiment consists of 6 treatments VIZ, T_1: sowing on 15 November, 07; T_2: sowing on 25 November, 07; T_3: sowing on 5 December, 07; T_4: sowing on 15 December, 07; T_5: sowing on 25 December, 07 and T_6: sowing on 4 January, 08. The field experiment was laid out in Randomized Complete Block Design (RCBD) and the laboratory experiment was laid out in a Complete Block Design (CRD). The healthy pod, infested pod and pod infestation by number and weight, average infestation by number and weight and yield of seed infestation in storage were recorded. The lowest average pod infestation per plant by number (6.62%) was recorded from T_3 and the highest (15.83%) was recorded from T_6. The minimum average pod infestation per plant by weight (7.35%) was recorded from T_1 and the maximum pod infestation per plant (16.94%) was recorded from T_6.The longest plant (87.83 cm) was recorded from T_3 and shortest plant (80.40 cm) was recorded in T_1. The highest yield (1.32 ton/ha) was recorded from T_3 and the lowest yield (1.20 ton/ha) was obtained from T_6. At 30, 40, 50, 60, 70, 80 and 90 DAS the lower seed infestation by number 5.56%, 5.78%, 7.56%, 8.67%, and 9.78%, respectively in Seeds of treatment T_3.On the other hand, the higher seed infestation by number were 16.00%, 16.67%, 18.67%, 19.33%, 20.67%, 21.33% and 23.78% at those DAS, respectively in Seeds of treatment T_6.

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CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the important pulse crops in Bangladesh and as well as in the world. The crop is locally known as "chola", "boot" or "botjam" in different parts of the country. It has been cultivated for centuries in India, Pakistan and Bangladesh. In Bangladesh, about 85% of the chickpea crop is grown in five greater districts of Faridpur, Jessore, Kustia, Rajshahi and Pabna districts (BBS, 2004). 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. It covers an area of 16,446 ha producing 11,980 tons 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 tradition in Bangladesh. 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 such as insect attack, flooding, poor quality seed etc. Among them, insect pest attack 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 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, average of 30 to 40 percent pods were found to be damaged by pod borer and it was estimated as 400 kg/ha yield losses. In favourable condition, the pod damage goes up 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.

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. But there is several bad effect of using chemical insecticide such as,insect resistance to insecticides, outbreaks of secondary pests, resurgence, adverse effects on non-target species etc. Therefore, non-chemical approach like cultural control may be effective for pest control.

A number of agronomic practices have been found to affect the yield of different crops (Boztok, 1985). Sowing time had a marked effect on growth and development of crops (Mittel and Srivastava, 1964). Optimum sowing time provides more time for the growth and development of plant which is favorable for higher yield where as both early and late sowing hinder the growth and development resulting lower yield.

Considering the present situation it is necessary to find out the optimum date of sowing for the management of chickpea pod borer both in field and storage. Therefore, the present study was planned and designed with the following objectives:

i. To study the effect of sowing dates on incidence and damage severity of pod borer in chickpea in field and pulse beetle in storage

ii. To find out the effective and optimum sowing dates by which damage can be minimized both the incidence of chickpea in field and pulse beetle in storage

CHAPTER II

REVIEW OF LITERATURE

The pod borer, *Helicoverpa armigera* (Hubner) is a serious pest of chickpea in Bangladesh and elsewhere. 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 as hosts of *H. armigera* at Patancheru, Andhra Pradesh, India, whereas 96 crops and 61 weeds and wild species have been recorded as host 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. In 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 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.

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 bypod borer.While and Reddy (1973) and Loganathan (1981) reported that pigeon pea was the preferred host for oviposition.The larvae feed on the foliage for some time and later bore into the pod (Plate 1).

Plate 1. Showing pod borer inside pod of chickpea

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 reported that from 14.00 to 16.00 hr of the day the males fly above the crop while the females were stationary and release a pheromone. During this period males were highly active and assembled around females. Loganathan (1981) observed peak mating activity at 16.00 hr of the day.

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 number 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 in india 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 in australia 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 in india 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 and 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 pale 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 (Plate 2). 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 planta of 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).

Plate 2. Showing larva of chickpea pod borer

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 were 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).

2.3.5 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.

2.3.6 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 longivity 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 and 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

Tajbakhsh and Saeid (2006) carried out a field study trial during 2005-2006 growing season to compare winter and spring sowing dates and studied the effect of plant density on the yield, yield components and some quality of morphological traits of one local cultivar chickpea (ghazvin). The study comprised of three sowing dates viz., mid November, mid March and mid April, four planting densities viz., 30×7.5, 30×10, 30×15 and 30×20 cm that representing 45, 34, 23

and 17 plant m^{-2}. The experiment was laid out in a split plot design, based on the completely randomized blocks. Results indicated that early sowing (mid November and mid March) crops produce higher yield as compared to mid April and plant density did not significantly affect the yield.

Bakr, *et al.* (2006) revealed that one hundred farmer-managed operational scale plots 0.5 bigha (0.067 ha) were established to compare an integrated crop management (ICM) package (including Botrytis grey mould (BGM) management components) with "normal farmer practice (NFP)" in selected upazilas of five districts in southwestern Bangladesh. The On-Farm Evaluations (OFEs) were laid out around a village. Components of the ICM package included a chickpea variety less susceptible to BGM, seed treatment with Bavistin [carbendazim] at 0.2%, reduced seed rate (37.5 kg/ha, as against the earlier recommended 50 kg/ha), delayed sowing (late November to mid-December), and need basal spraying of the fungicide, Bavistin (at 250 g/ha). The ICM package also included application of 20 kg P/ha as triple superphosphate and integrated management of pod borer (*Helicoverpa armigera*) by scouting for small larvae, placement of bird perches and need based application of insecticide spray (Ripcord [cypermethrin] at 250 ml/ha). Out of the 20 clusters, 10 clusters produced more than one t yield of which six produced yield ranging from 1300 to 1600 kg/ha. Among the rest of the 10, five produced above 900 kg yield. Compared to these, only 8 clusters in farmers' managed plots produced above one t and from the rest 12, nine clusters produced less than 800 kg/ha. Among the clusters producing more than one t, only three

produced above 1200 kg/ha yield. The mean BGM score in 19 clusters ranged from 1.0 to 3.0 in ICM package plots and 3.0 to 6.5 in FP plots.

Yigitoglu (2006) reported that highest seed yield of chickpea was obtained in early winter sowing and high plant density (45 plant m^{-2}). Planting density depends to environmental condition, seed size, plant type and method of sowing.

Singh *et al.* (2002) conducted on trial in Gurdaspur, Punjab, India, during 1999 and 2000 on chickpea cultivars PBG-1 and GL-769 to determine the effect of sowing dates (10 October, 20 October, 30 October, 10 November and 20 November) on *H. armigera* incidence. GL-769 showed the highest pod infestation (13.08 and 12.70% in 1999 and 2000, respectively), while PBG-1 showed the highest grain yield (1403.27 kg/ha in 1999 and 1414.27 kg/ha in 2000). Sowing at 10 October showed the lowest pod infestation (10.49% in 1999 and 10.08 in 2000) and highest grain yield (1410.66 kg/ha in 1999 and 1414.27 kg/ha in 2000).

Patnaik (2004) carried out a field trial on the effects of sowing date (30 October, 15 November, 30 November or 15 December) and row spacing (30 or 45 cm) on the incidence of H. *armigera* and yield of chickpea cultivars Annigeri-1, K 850 and H 208 in Keonjhar, Orissa, India. The sowing date had greater effects on pod damage and grain yield than the genotype. Crops sown on 30 October and 30 November had high grain yields (11.8-15.2 and 15.6-20.7 quintal/ha) despite the high levels of pod damage (4.6-11.1 and 14.5-16.7%) caused by *H. armigera.* However, based on yield and pod damage, sowing on 30 October was considered optimum. Closer spacing (30 cm) resulted in a higher mean number of eggs (5.0)

and larvae (8.2) per plant irrespective of sowing date and cultivar. Pod damage and grain yield did not significantly vary with the row spacing and cultivar.

Aditya *et al.* (2002) carried out a study on thirty eight early maturing and promising chickpea (*Cicer arietinum*) genotypes and evaluated at CSK, HPKV, Regional Research Station, Dhaulakuan, Himachal Pradesh, India under early (Env I & III) and late sown (Env II and IV) conditions during the year 1997-98 and 1998-99 against pod borer (*Helicoverpa armigera*). It was observed that both environments I and II of year 1997-98 were favourable for pod borer infestation. Pod borer infestation was more severe under late sown conditions as was evidenced by higher grand mean of 40.22 and 17.49% in Env. II and IV, respectively compared to 35.29 and 11.06% in early sown crop i.e., in Env. I and III. Erect of genotype 405#4 was highly resistant in all the four environments, whereas genotypes ICCV 88102, ICCV 88202, ICCV 90201, ICCV 88506, ICCV 910257 II and 910257 III have shown resistance to pod borer in two or three environments. The earliest maturing genotype, ICCV 2 was highly resistant under early sown conditions and moderately resistant under late sown conditions.

Manning *et al.* (2000) reported that the following aspects of chickpea production in New South Wales, Australia: an introduction to chickpeas and their cultivation in Australia; suitable environments for production; benefits of chickpea production; crop growth (including cultivars, seed quality, fallow, seedbed management, irrigation, row spacing, sowing times, sowing rates, seed

inoculation, sowing depth, fertilizers, weed control and insect control); harvesting; and marketing.

Singh *et al.* (1997) reported that Myanmar, Pakistan and turkey account for 26.9% of the winter-sown chickpea produced seed yield as 70% higher area and 22.6% of the production (Upadhyaya *et al.* than spring-sown crop in Syria. Iiiadis (2001) calculated 2001). Chickpea is the third major cool season grain 23-188% more seed for winter over spring sowing in legume crop in the world.

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

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.

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 30th October and 27 November sowings.

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 a study on the 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.

2.5 Infestation/Damage by pulse beetle in storage

A single larva of pulse beetle can destroy severe mature seeds (Howe and Currie, 1964; Singh, 1964).In case of its heavy infestation, the grains lost their germination capacity and became unfit for human consumption. Severe infestation led to 100% damage, thus leaving only seed coat. In addition to the quantitative losses, pulse beetle also caused quantitative losses and up to 90% losses were calculated in chickpea (Khare and Johari, 1984).In grub stage, the beetles live inside the grains and fills the burrows with their excrement and dead bodies (Atwal,1976), which within the kernels are ground into flour or meal. Millers are of the view that grains with more than 0.5% of insect infested kernels are unfit for milling (Cotton,1941).

According to Munroo (1966), the pulses were susceptible to the attack of insects before and after harvest, where the extent of infestation had been reported as

high as 70%.The damage caused to such an extent rendered the grains totally unfit for human and animal consumption. Modgil and Mehta (1996) observed the effect of pulse beetle infestation on the carbohydrate and dietary fiber contents of seeds of chickpea, green gram and pigeonpea at 10, 20, 30, 40, 50 and 60% infestation.Gupta et al. (1997) conducted a similar survey in different villages of districts Alwar and Jaipur of the Rajasthan province of India and reported up 20% damage by pulse beetle in stored green gram.

Kumari and Singh (1998) tested the efficacy of some botanicals against pulse beetle. Five types of botanical dusts were used as insecticide. Black pepper powder,neem leaf dust and mangraila powder were proved to be equally effective in respect of number of eggs laid, number of adults emerged and reduction in damage to grains by the pest.

Ghosh and Durbey (2003) found that temperature below 14˚c resulted in death particularly of immature stages of almost all insect pest. The optimal temperature for fecundity and development of stored product insects was between 25˚c and 35˚c while temperatures between 13˚c and 25˚c made the development of insects (metabolic activity) slower. Most of the stored product insects stopped their development at 20˚c.they further revealed that most of the stored grain insects died at 50˚c to 60˚c within a period of 10 t 20 minutes.

In studies by Arthur (2006), temperature was increased gradually by 0.1˚c per minute compared to sudden temperature increases in the prevailing studies. The mortality of stored beetles remained less but there was no mortality after initial

exposure or after one week holding period of any life stage of these beetles exposed to 36, 39 or 42˚c for 32 hours. The exposure of two and one hour at 51˚c and 54˚c, respectively, killed all life stages.

Temperature selection might be affected by humidity or state of hydration of the insect (Chapman, 1965).They might together affect fecundity and longevity markedly.Lale and Vidal (2003) evaluated four temperature (25˚c,30˚c,35˚c and 40˚c) and three humidity level (30%,60% and 90% r.h.) for their effect on ovipositor and development of stored beetle in pure and mixed populations on groundnut. Where temperature influenced ovipositor significantly more than humidity.

CHAPTER III

MATERIALS AND METHODS

The studies were carried out at research farm and laboratory of Entomology department in Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, and Dhaka, Bangladesh during the period from November, 2007 to July, 2008 to find out the effect of dates of sowing on the incidence of chickpea pod borer in field and pulse beetle in storage. The materials and methods used in this study have been presented under the following sub headings-

Experiment 1: Effect of dates of sowing on the incidence of chickpea pod borer in field condition

General consideration

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, and 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 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). Details of the metrological data related to the temperature, relative humidity and rainfalls during the period of the study was collected from the Bangladesh Meteorological Department, Dhaka.

3.1.4 Land preparation

The selected experimental field was opened in the first week of November 2007 with a power tiller and was exposed to the sun for a week for sun drying. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth for the growth of chickpea seedlings. Weeds and stubbles were removed and finally obtained a desirable tilth of soil. The field was partitioned into unit plots in accordance with the experimental design. The target land was divided into 18 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

Well decomposed cowdung as per recommendation was applied at the time of final land preparation (Rashid, 1993). 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 dose at the

time of main field preparation. Finally urea applied as top dressing before flowering stage.

3.1.6 Seed source and seed treatment

The Seeds of variety BARI Chola-5 of chickpea were collected from Bangladesh Agricultural Research Institute, Gazipur, Dhaka. Germination test was done 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 15 November 2007 in rows with as spacing of 50 cm. The populations of the plants were maintained at constant level by keeping plant-to-plant distance of 10 cm. Another five sowing dates were 25 November, 5, 15, 25 December and 4 January of the year 2008.

3.1.8 Treatments

There were 6 sowing dates with 10 days interval starting from 15 November, 2007 to 4 January, 2008 during rabi season. 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 15 November' 07
T_2: Sowing on 25 November' 07
T_3: Sowing on 5 December' 07
T_4: Sowing on 15 December' 07
T_5: Sowing on 25 December' 07
T_6: Sowing on 4 January' 08

3.1.9 Experimental design and layout

The experiments were laid out in randomized complete block design (RCBD) finally with three replications. The treatments were randomly allotted in each block (Plate 3). 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.

Plate 3. Showing plot in the field.

3.1.10 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.

3.1.11 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 study. Pod borer population per plant was recorded at weekly intervals from the randomly tagged 5 plants in central rows and starting from flowering to pod maturity. The entire period were divided into early, mid and late fruiting stage and percentage of pod damage due to pod borer was also calculated from the pods of 5 randomly selected plants from the central rows in number and weight basis.

3.1.12 Determination of pod borer damage by number

All the pods were counted from 5 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:

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

3.1.13 Determination of pod borer damage by weight

All the pods were counted from 5 randomly selected plants from middle rows of each plot and examined. The damaged (bored) and total numbers of pods were weighed and the percent pod damage was calculated using the following formula:

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

3.1.14 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.

Experiment 2: Effect of dates of sowing on the incidence of pulse beetle in storage

In storage 150 seeds were plated as per the sowing dates designed at CRD with three replications (Plate 4). After 30 DAS (Days after storage) infested seed were counted at 10 days interval up to 90 (DAS) and infestation was calculated by using the following formula-

$$\% \text{ Seed infestation} = \frac{\text{Number of damaged seed}}{150} \times 100$$

3.3 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the mean difference among the treatment combinations was estimated by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Two studies were conducted to find out the effect of dates of sowing on the incidence of chickpea pod borer in field and pulse beetle in storage. The analysis of variance (ANOVA) of the data on number and weight of healthy pod, infested pod and pod infestation in number and weight, average infestation by number and by weight, yield contributing characters and yield of chickpea by chickpea pod bore in field and seed infestation in storage by pulse beetle are given in Appendix II-V. The results have been presented and discussed, and possible explanations have been given under the following headings and subheadings:

4.1 Pod bearing status by number

4.1.1 Early fruiting stage

At early fruiting stage for different dates of sowing showed statistically significant variation by number of healthy pod per plant (Appendix II). The highest number of healthy pod per plant (23.80) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (22.10, 22.07 and 21.93) to T_4 (sowing on 15 December), T_5 (sowing on 25 December, 07) and T_6 (sowing on 4 January, 07), respectively (Table 1). On the other hand, the lowest number of healthy pod (20.40) was recorded in T_1 (sowing on 15 November, 07) treatment which was statistically similar (21.40) to T_2 (sowing on 25 November, 07).

Table 1. Effect of different dates sowing on the incidence of chickpea pod borer at early, mid and late fruiting stages in terms of fruit per plant by number

Treatment	Early stage			Mid stage			Late stage		
	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation
T_1	20.40 b	1.40 c	6.47 c	36.40 c	2.90 d	7.39 de	48.00 bc	4.27 f	8.18 d
T_2	21.40 b	1.60 c	6.94 bc	39.30 abc	3.27 d	7.67 d	52.00 ab	4.83 e	8.51 d
T_3	23.80 a	1.27 c	4.90 c	42.10 a	2.63 d	5.88 e	54.00 a	5.37 d	9.03 d
T_4	22.10 ab	2.17 b	8.94 b	41.00 ab	4.73 c	10.36 c	50.00 abc	7.37 c	12.87 c
T_5	22.07 ab	3.30 a	13.05 a	38.23 bc	6.27 b	14.09 b	48.00 bc	8.80 b	15.50 b
T_6	21.93 ab	3.63 a	14.21 a	38.13 bc	7.37 a	16.20 a	47.00 c	9.67 a	17.08 a
$LSD_{(0.05)}$	1.881	0.364	2.053	2.945	0.787	1.683	3.972	0.502	1.367
CV(%)	4.71	8.97	12.42	4.13	9.54	9.02	4.38	4.10	6.34

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December' 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

The lowest number of infested pod per plant (1.27) was recorded from T_3 treatment which was statistically similar to T_1 (1.40) and T_2 (1.60), and closely followed by T_4 (2.17) While the highest number of infested pod (3.63) was recorded in T_6 treatment which was statistically identical to T_5 (3.30) treatment (Table 1).

The lowest pod infestation per plant by number (4.90%) was recorded from T_3 treatment which was statistically similar to T_1 (6.47%) and T_2 (6.94%) and closely followed by T_4 (8.94%). Again, the highest pod infestation per plant (14.21%) was recorded from T_6 treatment which was closely followed by T_5 (13.05%) treatment (Table 1).

4.1.2 Mid fruiting stage

Significant difference was recorded in number of healthy pod per plant at mid fruiting stage in different sowing dates (Appendix II). The highest number of healthy pod per plant (42.10) was recorded from T_3 (sowing on 5 December, 07) treated plots which was statistically similar (41.00 and 39.30) to those of T_4 (sowing on 15 December) and T_2 (sowing on 25 November, 07) and was closely followed (38.23 and 38.13) by T_5 (sowing on 25 December, 07) and T_6 (sowing on 4 January, 07), (Table 1). On the other hand, the lowest number of healthy pod (36.40) was recorded in T_1 (sowing on 15 November, 07) treated plots.

The lowest number of infested pod per plant (2.63) was recorded from T_3 treatment which was statistically similar to those of T_1 (2.90) and T_2 (3.27), and was closely followed by T_4 (4.73) treated plots. Whereas as, the highest number of

infested pod (7.37) was recorded in T_6 treated plots which was statistically identical to T_5 (6.27) treatment (Table 1).

The lowest pod infestation per plant in number (5.88%) was recorded from T_3 treatment which was statistically similar to T_1 (7.39%) treatment and followed by T_2 (7.67%). On the other hand, the highest (16.20%) was recorded from T_6 treatment which was followed by T_5 (14.20%) treatment (Table 1).

4.1.3 Late fruiting stage

Statistically significant variation was recorded in number of healthy pod per plant at late fruiting stage in different dates of sowing (Appendix II). The highest number of healthy pod per plant (54.00) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (52.00 and 50.00) to T_2 (sowing on 25 November, 07) and T_4 (sowing on 15 December, 07), treatments (Table 1). On the other hand, the lowest number of healthy pod (47.00) was recorded in T_6 (sowing on 4 January, 08) treated plots which was statistically similar (48.00) to T_1 (sowing on 15 November, 07) and T_5 (sowing on 25 December, 07), treatments.

At late fruiting stage at different dates of sowing under the present trial showed statistically significant variation in number of infested pod per plant (Appendix II). The lowest number of infested pod per plant (4.27) was recorded from T_1 treated plots which was followed by T_2 (4.83). Again, the highest

number of infested pod (9.67) was recorded in T_6 treated plots which was followed by T_5 (8.80) treatment (Table 1).

The lowest pod infestation per plant in number (8.18%) was recorded from T_1 treated plots which was statistically similar to T_2 (8.51%) and T_3 (9.03%) and was followed by T_4 (12.87%) treated plots. On the other hand, the highest pod infestation per plant (17.08%) was recorded from T_6 treated plots which was followed by T_5 (15.08%) treatment (Table 1).

These results indicate that there was a significant effect of sowing dates on pod infestation by pod borer in number at all growing stages. But the dates of sowing on 5 December showed minimum infestation in number compared to other dates of sowing. Tajbakhsh and Saeid (2006), Singh *et al.* (2002), Aditya *et al.*, (2002), Manning *et al.* (2000) and Ahmadi and kanoni (1994) reported similar results from their earlier studies. They indicated that early sowing (mid November and mid March) chickpea produce higher yield as compared to mid April and plant density did not significantly affect the yield.

4.2 Pod bearing status by weight

4.2.1 Early fruiting stage

Statistically significant variation was recorded in weight of healthy pod per plant at early fruiting stage at different dates of sowing (Appendix III). The maximum weight of healthy pod per plant (216.96 g) was recorded from T_3 (sowing on 5 December, 07) treated plots which was statistically similar (203.01 g, 202.32 g and 202.01 g) to T_5 (sowing on 25 December), T_4 (sowing on 15 December, 07) and T_6 (sowing on 4 January, 07), treatments (Table 2). Again, the minimum weight of healthy pod (186.35 g) was recorded in T_1 (sowing on 15 November, 07) treated plots which was statistically similar (196.88) to T_2 (sowing on 25 November, 07) treated plots.

The minimum weight of infested pod per plant (13.87 g) was recorded from T_3 treated plots which was statistically similar to T_1 (14.86 g) and was followed by T_2 (16.84 g). But the maximum (37.30 g) was recorded from T_6 treated plots which was followed by T_5 (34.30 g) treated ones (Table 2).

The minimum pod infestation per plant by weight (6.01%) was recorded from T_3 treated plots which was followed by those of T_1 (7.40%) and T_2 (7.88%) treatments. On the other hand, the maximum pod infestation per plant (15.57%) was recorded from T_6 treated plots which was followed by T_5 (14.37%) treatment (Table 2).

Table 2. Effect of different dates sowing on the incidence of chickpea pod borer at early, mid and late fruiting stages in terms of fruit per plant by weight

Treatment	Early stage			Mid stage			Late stage		
	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation
T_1	186.35 b	14.86 de	7.40 d	353.08 c	30.54 d	7.97 d	499.20 bc	47.51 f	8.70 e
T_2	196.88 b	16.84 d	7.88 d	381.21 abc	33.65 d	8.11 d	540.80 ab	54.35 e	9.13 de
T_3	216.96 a	13.87 e	6.01 e	408.37 a	27.79 d	6.37 d	561.60 a	60.16 d	9.67 d
T_4	202.32 ab	22.45 c	9.99 c	397.70 ab	49.42 c	11.07 c	520.00 abc	82.30 c	13.68 c
T_5	203.01 ab	34.00 b	14.37 b	370.86 bc	65.21 b	14.96 b	499.20 bc	95.92 b	16.12 b
T_6	202.12 ab	37.30 a	15.57 a	369.89 bc	76.88 a	17.22 a	488.80 c	107.35 a	18.02 a
$LSD_{(0.05)}$	16.42	2.674	1.126	28.57	6.784	1.677	41.31	3.839	0.899
CV(%)	4.48	6.33	6.06	4.13	7.89	8.42	4.38	2.83	3.93

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.2.2 Mid fruiting stage

At mid fruiting stage in different dates of sowing showed statistically significant variation in weight of healthy pod per plant (Appendix III). The maximum weight of healthy pod per plant (408.37 g) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (397.70 g and 381.21 g) to those of T_4 (sowing on 15 December, 07) and T_2 (sowing on 25 November, 07) treatments and was followed (370.86 g and 369.89 g) by T_5 (sowing on 25 December, 07) and T_6 (sowing on 4 January, 08), treated plots (Table 2). On the other hand, the minimum weight of healthy pod (353.08 gm) was recorded in T_1 (sowing on 15 November, 07) treated plots.

The minimum weight of infested pod per plant (27.79 g) was recorded from T_3 treated plots which was statistically similar to those of T_1 (30.65 g) and T_2 (33.65 g) treatments and was followed by T_4 (49.42 g). On the other hand, the maximum weight of infested pod (76.88 g) was recorded in T_6 treated plots which was followed by T_5 (65.21 g) treatment (Table 2).

The minimum pod infestation per plant by weight (6.37%) was recorded from T_3 treated plots which was statistically similar to those of T_1 (7.97%) and T_2 (8.11%) treatments. Again, the maximum pod infestation per plant (17.22%) was recorded from T_6 treated plots which was followed by T_5 (14.96%) treatment (Table 2).

4.2.3 Late fruiting stage

Statistically significant variation was recorded in weight of healthy pod per plant at late fruiting stage at different dates of sowing (Appendix III). The maximum

weight of healthy pod per plant (561.60 g) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (540.80 g and 520.00 g) to that of T_2 (sowing on 25 November, 07) and T_4 (sowing on 15 December, 07) treated plots (Table 2). On the other hand, the minimum weight of healthy pod (488.80 g) was recorded in T_6 (sowing on 4 January, 08) treatment which was statistically similar (499.29 g) to that of T_1 (sowing on 15 November, 07) and T_5 (sowing on 25 December, 07) treated plots.

The minimum weight of infested pod per plant (47.51 g) was recorded from T_1 treatment which was followed by that of T_2 (54.35 g) treatments While the maximum weight of infested pod (107.35 g) was recorded in T_6 treatment which was followed by T_5 (95.92 g) treatment (Table 2).

The minimum pod infestation per plant by weight (8.70%) was recorded from T_1 treatment which was statistically similar to that of T_2 (9.13%) and was followed by T_3 (9.67%) treatments. On the other hand, the maximum pod infestation per plant (18.02%) was recorded from T_6 treatment which was followed by T_5 (16.12%) treatment (Table 2).

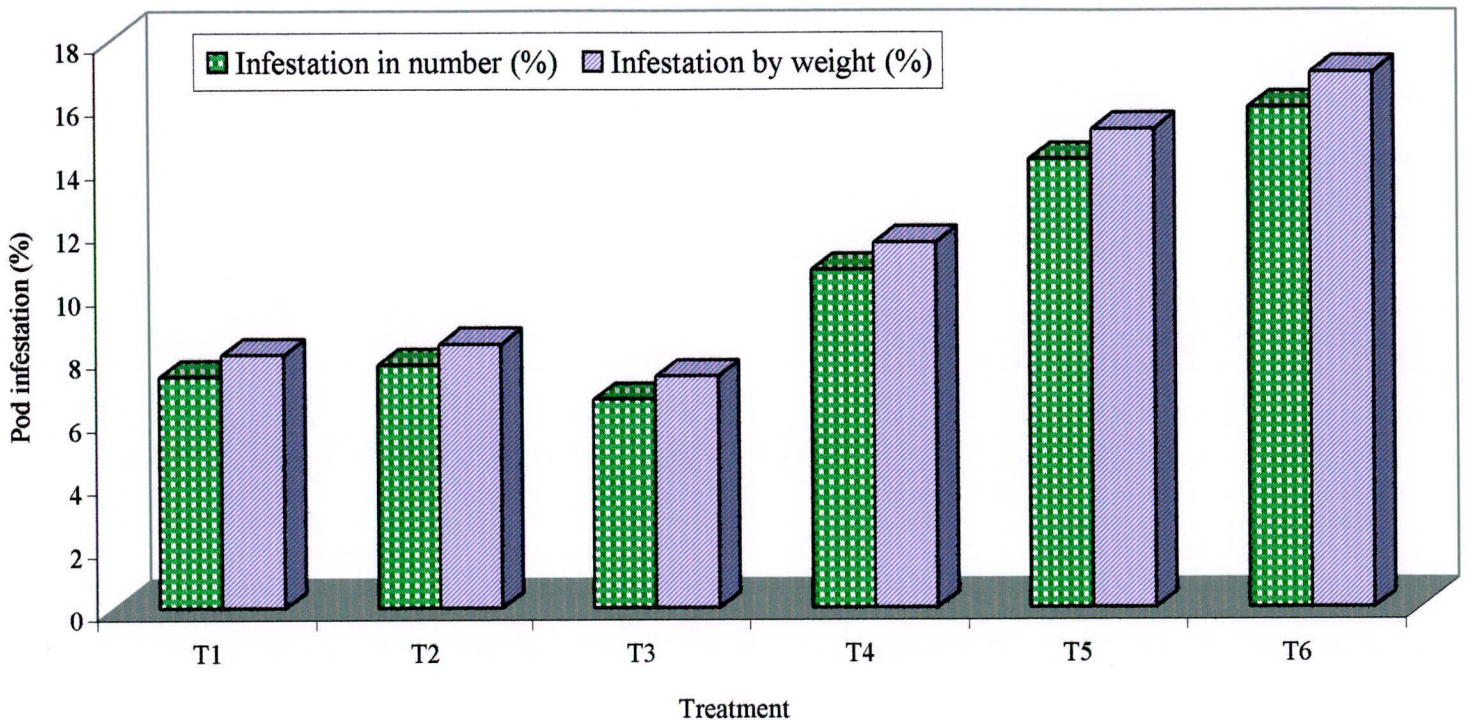
These results indicate that there was a significant effect of dates of sowing on pod infestation by weight at all growing stages. But the date of sowing on 5 December showed the minimum infestation by weight compared to that of the others dates of sowing. Singh *et al.,* (2002), Aditya *et al.,* (2002), Manning *et al.,* (2000) and Ahmadi and kanoni (1994) reported similar results from their studies. It was observed that both environments I and II of year 1997-98 were favourable for pod

borer infestation. Pod borer infestation was more severe under late sown conditions as was evidenced by higher grand mean of 40.22 and 17.49% in Env. II and IV, respectively compared to 35.29 and 11.06% in early sown crop i.e. in Env. I and III. Erect type genotype 405#4 was highly resistant in all the four environments, whereas genotypes ICCV 88102, ICCV 88202, ICCV 90201, ICCV 88506, ICCV 910257 II and 910257 III have shown resistance to pod borer in two or three environments. The earliest maturing genotype, ICCV 2 was highly resistant under early sown dates and moderately resistant under late sown dates.

4.3 Average infestation by number and by weight

Average pod infestation per plant by number at different dates of sowing showed significant variation (Appendix II). The lowest average pod infestation per plant by number (6.62%) was recorded from T_3 treated plots which was statistically similar to that of T_1 (7.35%) and T_2 (7.71%) treatments and was followed by T_4 (10.72%) treatment. Again, the highest average pod infestation per plant (15.83%) was recorded from T_6 treated plots which was followed by T_5 (14.21%) treatment (Figure 1).

The minimum average pod infestation per plant byweight (7.35%) was recorded from T_1 treatment which was numerically similar to that of T_2 (8.03%) and was followed by T_3 (8.37%) treatment. Again, the maximum pod infestation per plant (16.94%) was recorded from T_6 treated plots which was followed by T_5 (15.15%) treatment (Figure 1).



T_1: Sowing on 15 November' 07; T_2: Sowing on 25 November' 07
T_3: Sowing on 5 December' 07; T_4: Sowing on 15 December' 07
T_5: Sowing on 25 December' 07; T_6: Sowing on 4 January' 08

Figure 1. Effect of dates of sowing on the pod infestation of chickpea by pod borer in the field

4.4 Relationship between average pod infestation by number & by weight and temperature & humidity

4.4.1 Relationship between pod infestation by number and temperature

The data on pod infestation in number were regressed against temperature and a positive relationship was obtained between them. It was evident from the Figure 2 that the equation $y = -0.3273x + 27.523$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.835$) showed that, fitted regression line had a significant regression co-efficient. It is evident from the equation that, the pod infestation in number increased with the increased of temperature.

4.4.2 Relationship between pod infestation by number and relative humidity

Correlation study was done to establish a relationship between pod infestation in number and relative humidity (%). From the study it was revealed that significant correlations existed between the characters (Figure 3). The regression equation $y = -1.2172x + 86.165$ gave a good fit to the data and the value of the co-efficient of determination ($R^2 = 0.774$). From this it can be concluded that there were a significant relationship between pod infestation by number and relative humidity.

4.4.3 Relationship between pod infestation by weight and temperature

The data on pod infestation in weight were regressed against temperature and a positive linear relationship was obtained between them. It was evident from the Figure 4 that the equation $y = -0.3145 + 27.651$ gave a good fit to the data, and the co-efficient of determination ($R^2 = 0.838$) showed that, fitted regression line had a significant regression co-efficient. It is evident from the equation that, the pod infestation in weight increased with the increased of temperature.

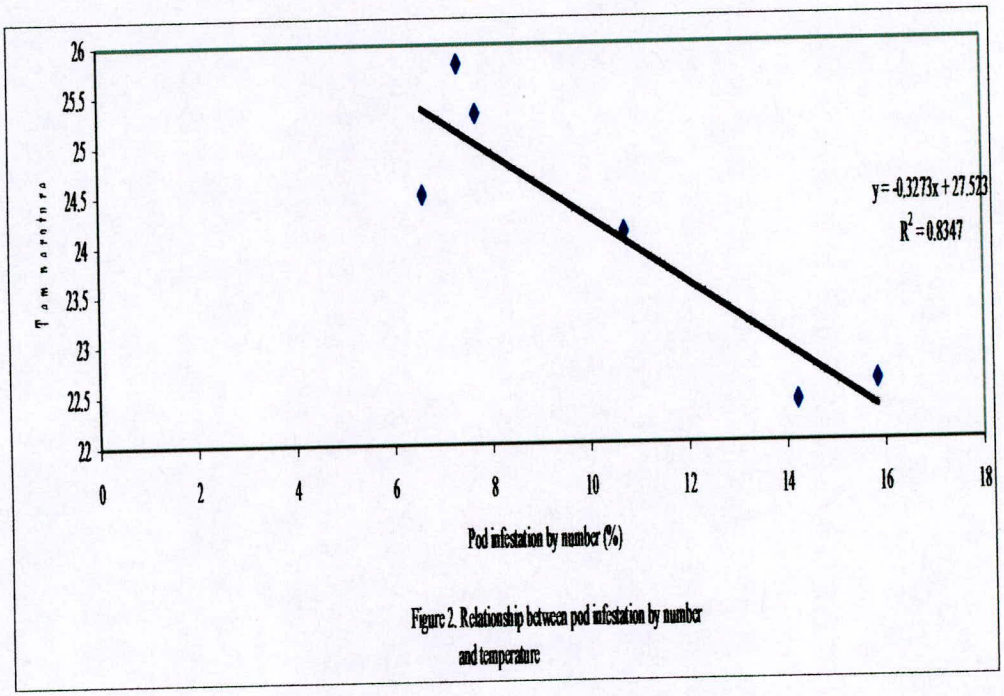


Figure 2. Relationship between pod infestation by number and temperature

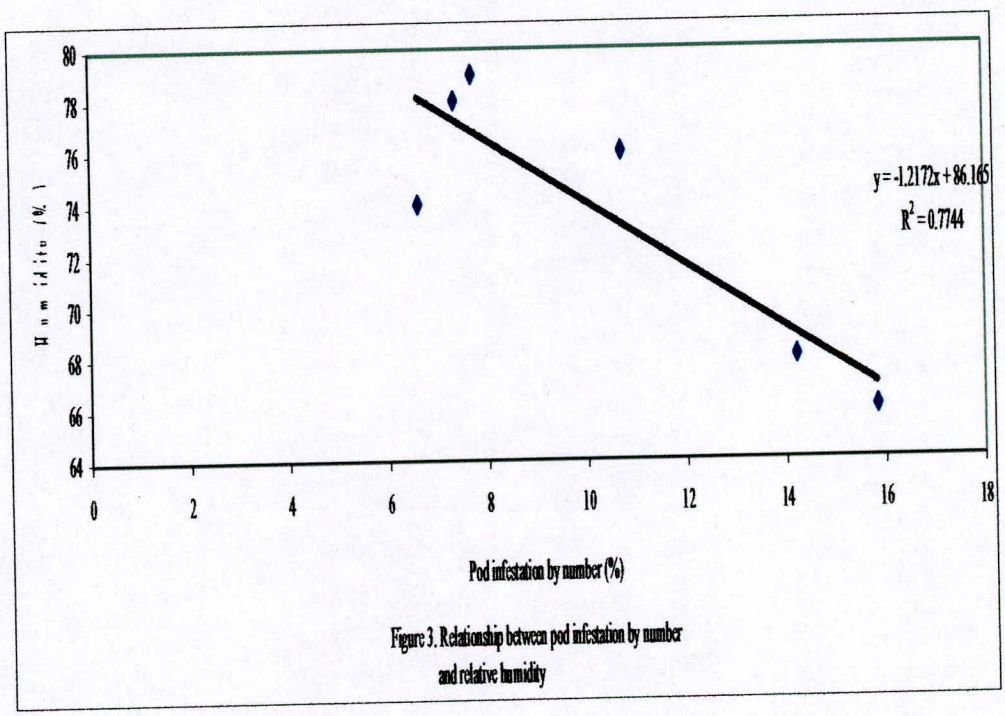


Figure 3. Relationship between pod infestation by number and relative humidity

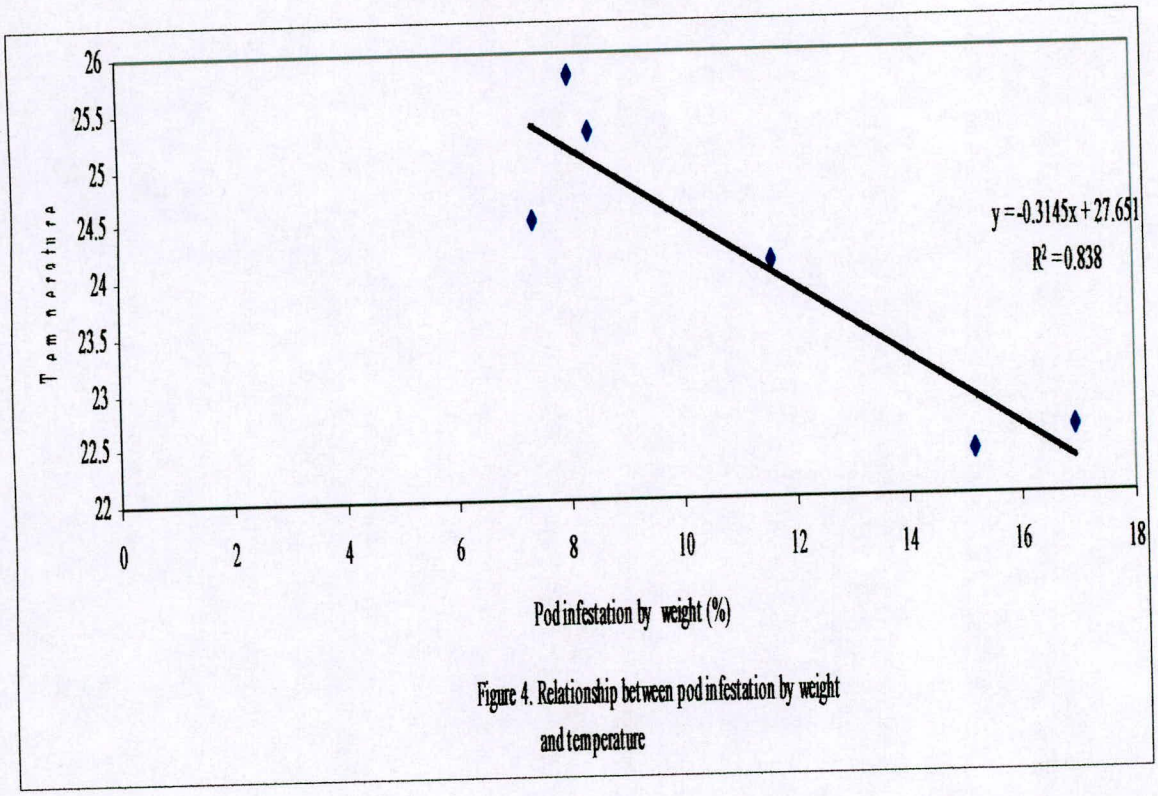


Figure 4. Relationship between pod infestation by weight and temperature

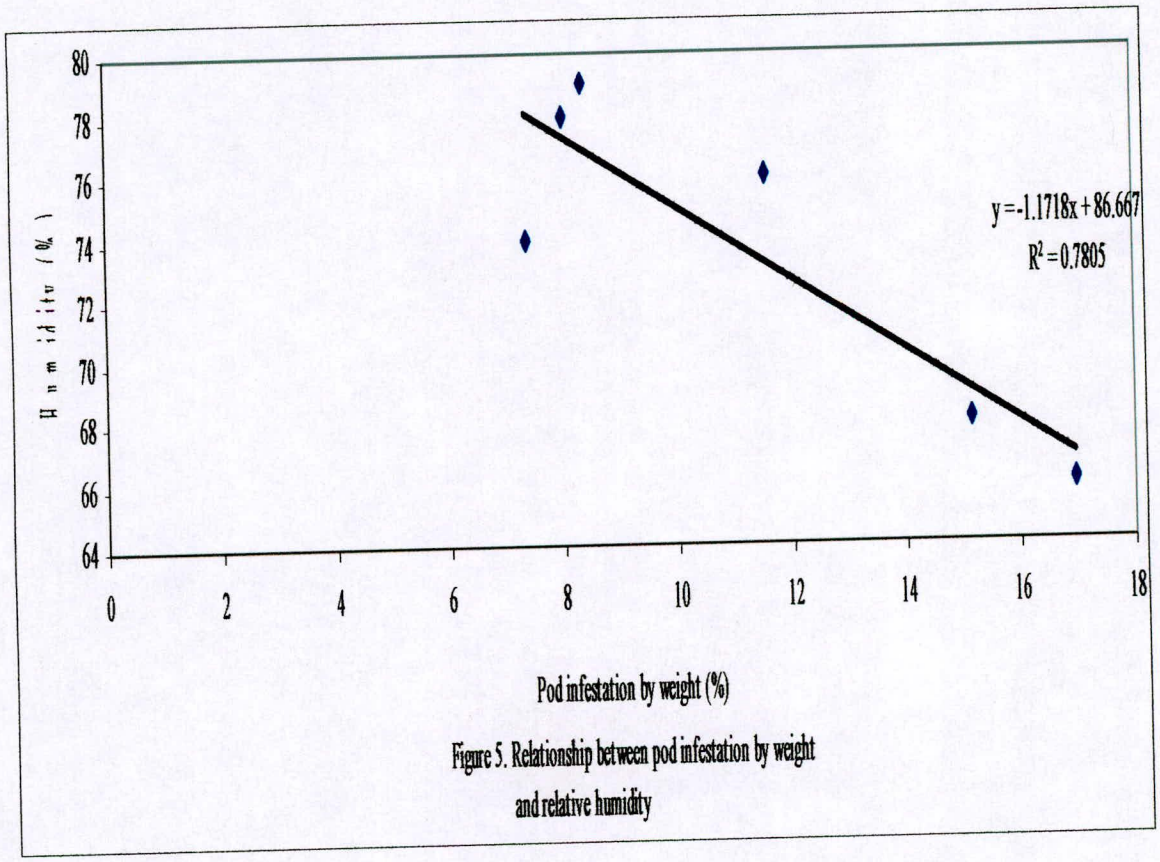


Figure 5. Relationship between pod infestation by weight and relative humidity

4.4.4 Relationship between pod infestation by weight and relative humidity

Correlation study was done to establish a relationship between pod infestation in weight and relative humidity (%). From the study it was revealed that a significant correlation existed between the characters (Figure 5). The regression equation y = -1.1718x + 86.667 gave a not good fit to the data and the value of the co-efficient of determination (R^2 = 0.781). From this it can be concluded that there were a significant relationship between pod infestation in weight and relative humidity

4.5 Yield contributing characters and yield

4.5.1 Plant height

Plant height of chickpea showed statistically significant variation at different dates of sowing (Appendix IV). The longest plant (87.83 cm) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (85.13 cm, 85.03 and 83.47 cm) to that of T_2 (sowing on 25 November, 07) and T_4 (sowing on 15 December, 07) and T_5 (sowing on 25 December, 07), treatments (Figure 6). Again, shortest plant (80.40 cm) was recorded in T_1 (sowing on 15 November, 07) treatment which was statistically similar (82.67 cm) to that T_6 (sowing on 4 January, 08) treated plots.

4.5.2 Number of branches per plant

Statistically significant variation was recorded in terms of number of branches per plant of chickpea at different dates of sowing (Appendix IV). The highest number of branches per plant (4.93) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (4.83) to that of

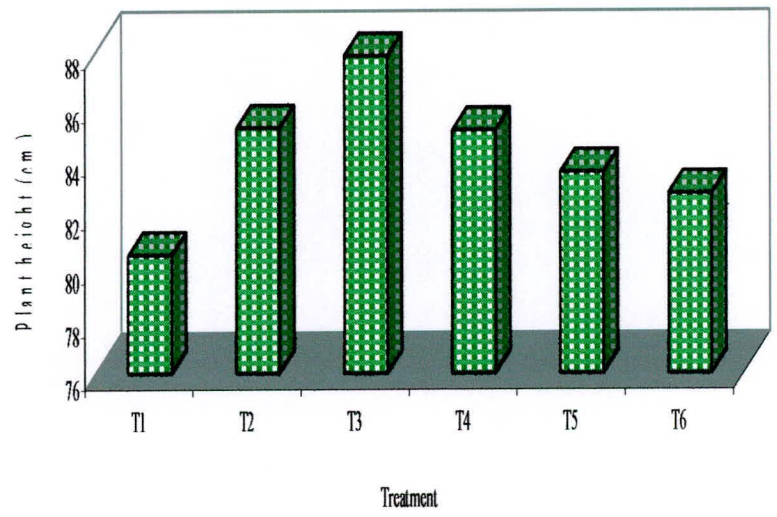


Figure 6. Effect of sowing dates on plant height of chickpea

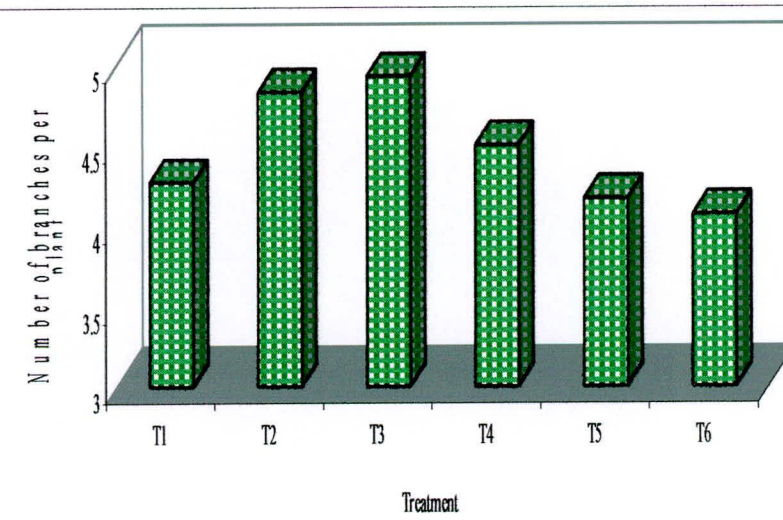


Figure 7. Effect of sowing date on number of branches per plant of chickpea

T1: Sowing on 15 November' 07; T2: Sowing on 25 November' 07

T3: Sowing on 5 December' 07; T4: Sowing on 15 December' 07

T5: Sowing on 25 December' 07; T6: Sowing on 4 January' 08

T_2 (sowing on 25 November, 07) treatment and was followed (4.50) by T_4 (sowing on 15 December, 07) treatment (Figure 7). On the other hand, the lowest number of branches per plant (4.07) was recorded in T_6 (sowing on 4 January, 08) treatment which was statistically similar (4.07 and 4.27) to that of T_5 (sowing on 25 December, 07) and T_1 (sowing on 15 November, 07) treated plots.

4.5.3 Number of leaves per plant

Different dates of sowing dates showed statistically significant difference in terms of number of leaves per plant of chickpea (Appendix IV). The highest number of leaves per plant (42.40) was recorded from T_3 (sowing on 5 December, 07) treatment which was followed (39.87, 39.67 and 39.20) by T_4 (sowing on 15 December, 07), T_2 (sowing on 25 November, 07) and T_5 (sowing on 25 December, 07) treatments (Table 3), respectively. On the other hand, the lowest number of leaves per plant (35.93) was recorded in T_1 (sowing on 15 November, 07) treatment which was statistically similar (37.50) to T_6 (sowing on 4 January, 08) treatment.

4.5.4 Number of pods per plant

Statistically significant variation was recorded in terms of number of pods per plant of chickpea at different dates of sowing (Appendix IV). The highest number of pods per plant (66.63) was recorded from T_6 (sowing on 4 January, 08) treatment which was followed (63.10 and 62.80) is T_5 (sowing on 25 December, 07) and T_4 (sowing on 15 December, 07) treatments (Table 3), respectively. On the other hand, the lowest number of pods per plant (56.50) was

Table 3. Effect of different dates of sowing on the yield contributing characters and yield of chickpea

Treatment	Number of leaves per plant	Number of pods per plant	Pod length (cm)	Weight of 100 seeds (g)	Yield (t/ha)
T_1	35.93 c	56.50 d	4.52 ab	126.87 b	1.21 cd
T_2	39.67 b	59.07 cd	4.65 ab	128.15 b	1.23 bcd
T_3	42.40 a	61.40 bc	4.72 a	137.07 a	1.32 a
T_4	39.87 b	62.80 b	4.62 ab	128.00 b	1.29 ab
T_5	39.20 b	63.10 b	4.35 bc	123.00 b	1.27 abc
T_6	37.50 bc	66.63 a	4.22 c	113.17 c	1.20 d
$LSD_{(0.05)}$	2.450	3.122	0.282	7.200	0.058
CV(%)	3.45	2.79	3.41	3.14	2.63

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

recorded in T_1 (sowing on 15 November, 07) treatment which was statistically similar (59.07) to T_2 (sowing on 25 November, 07) treatment.

4.5.5 Pod length

Pod length of chickpea at different dates of sowing showed statistically significant difference (Appendix IV). The maximum pod length (4.72 cm) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (4.65 cm, 4.62 cm and 4.52) to T_2 (sowing on 25 November, 07), T_4 (sowing on 15 December, 07) and T_1 (sowing on 15 November, 07) treatments, respectively (Table 3). On the other hand, the minimum pod length (4.22 cm) was recorded in T_6 (sowing on 4 January, 08) treatment which was statistically similar (4.35 cm) to that of T_5 (sowing on 25 December, 07) treatment.

4.5.6 Weight of 100 seeds

Statistically significant variation was recorded in terms of weight of 100 seeds of chickpea at different dates of sowing (Appendix IV). The maximum weight of 100 seeds (137.07 g) was recorded from T_3 (sowing on 5 December, 07) treatment which was followed (128.15 g, 128.00 g, 126.87 g and 123.00 g) by T_2 (sowing on 25 November, 07), T_4 (sowing on 15 December, 07), T_1 (sowing on 15 November, 07) and T_5 (sowing on 25 December, 07) treatments (Table 3), respectively. On the other hand, the minimum weight of 100 seeds (113.17 g) was recorded in T_6 (sowing on 4 January, 08) treatment.

4.5.7 Yield per hectare

Yield per hectare of chickpea at different dates of sowing showed statistically significant variation (Appendix IV). The highest yield (1.32 ton/ha) was recorded from T_3 (sowing on 5 December, 07) treatment which was statistically similar (1.29 ton/ha and 127 ton/ha) to T_4 (sowing on 15 December, 07) and T_5 (sowing on 25 December, 07) treatments (Table 3). On the other hand, the lowest yield (1.20 ton/ha) was recorded from T_6 (sowing on 4 January, 08) treatment which was statistically comparable (1.21 ton/ha) to T_1 (sowing on 15 November, 07) treatment.

4.6 Seed infestation by pulse beetle in storage

Statistically significant variation was recorded for seed infestation at different days after storage (DAS) of seeds collected from plots of different dates of sowing (Appendix V). At 30, 40, 50, 60, 70, 80 and 90 DAS the lowest seed infestation by number (5.56%, 5.78%, 7.56%, 8.67%, and 9.78%) was recorded from seeds of T_3 treatment. On the other hand, the highest seed infestation by number (16.00%, 16.67%, 18.67%, 19.33%, 20.67%, 21.33% and 23.78%) was recorded from seed of T_6 treatment (Table 4). It was found that the infestation of chickpea seed increased with the increased of storage period and the highest infestation were recorded from seeds of late sowing compared to early sowing. Sowing dates of chickpea in middle period is the best for reduction seed infestation in storage compared to those of early and late sowing.

4.7 Number of egg under storage condition

Statistically significant variation was recorded for number of egg at different days after storage (DAS) of seeds collected from plots of different dates of sowing (Appendix VI). At 30, 40, 50, 60, 70, 80 and 90 DAS the minimum number of eggs (5.13, 6.67, 10.05, 13.26, 13.85, 18.52 and 20.33) was recorded from seeds of T_3 treatment. On the other hand, the maximum number of eggs (6.15, 20.00, 39.68, 43.68, 51.24, 53.38 and 58.05) was recorded from seeds of T_6 treatment (Table 4). It was found that the number of eggs on the seed increased with the increased storage period and the highest infestation was recorded from seeds of late dates of sowing compare to early date. Sowing dates of middle period is the

best for reducing seed infestation in storage compared to those of early and late dates of sowing.

Table 4. Effect of different dates of sowing on the number of pulse beetle eggs under storage condition

Treatment	Number of eggs at						
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
T_1	5.38 cd	10.00 bc	12.05 d	19.85 d	18.00 c	26.74 d	30.64 d
T_2	5.62 bc	6.67 c	11.64 d	13.74 e	13.33 d	19.05 e	21.28 e
T_3	5.13 d	6.67 c	10.05 d	13.26 e	13.85 d	18.52 e	20.33 e
T_4	5.95 ab	10.00 bc	19.33 c	25.22 c	21.38 c	31.02 c	35.78 c
T_5	6.03 a	16.67 ab	24.32 b	30.08 b	28.75 b	35.45 b	41.35 b
T_6	6.15 a	20.00 a	39.68 d	43.68 a	51.24 a	53.38 a	58.05 a
$LSD_{(0.05)}$	0.365	8.107	3.558	4.633	3.537	4.108	3.839
CV(%)	9.73	4.55	10.53	11.49	8.73	8.10	6.76

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 5. Effect of different dates of sowing on the number of larvae of pulse beetle under storage condition

Treatment	Number of larvae at						
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
T_1	4.67 c	8.67 c	9.67 d	12.00 c	11.00 d	16.33 c	14.99 d
T_2	4.00 c	8.00 c	10.00 d	10.33 d	13.00 c	13.00 d	13.37 e
T_3	3.00 d	6.33 d	8.00 e	8.33 e	9.67 e	12.67 d	11.37 f
T_4	4.00 c	8.00 c	11.33 c	11.00 cd	14.33 c	16.67 c	17.83 c
T_5	6.33 b	11.67 b	13.00 b	14.00 b	15.67 b	19.00 b	22.75 b
T_6	8.33 a	13.00 a	14.67 a	16.67 a	19.00 a	22.33 a	27.78 a
$LSD_{(0.05)}$	0.792	1.317	0.654	0.978	1298	1.848	0.705
CV(%)	8.91	8.05	3.31	4.56	5.26	6.25	2.39

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 6. Effect of different dates of sowing on the number of pulse beetle pupae under storage condition

Treatment	Number of pupae at						
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
T_1	3.83 b	9.17 ab	11.57 a	13.43 bc	16.33 b	21.50 a	28.50 a
T_2	3.99 b	10.46 a	11.88 a	13.57 bc	17.60 ab	22.40 a	29.73 a
T_3	3.44 b	7.51 b	9.07 b	11.49 c	15.64 b	18.35 b	24.08 b
T_4	3.98 b	9.36 a	12.45 a	15.57 ab	19.38 a	22.40 a	28.75 a
T_5	4.93 a	10.10 a	12.80 a	15.77 ab	19.81 a	23.25 a	29.73 a
T_6	4.79 a	10.32 a	13.05 a	16.30 a	19.90 a	24.02 a	30.85 a
$LSD_{(0.05)}$	0.532	1.750	1.446	2.321	2.220	2.996	2.995
CV(%)	9.00	13.25	8.77	11.54	8.68	9.41	7.23

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 7. Effect of different dates of sowing on the number of pulse beetle adults under storage condition

Treatment	Number of adult at						
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
T_1	1.22 abc	2.88 bc	5.19 c	5.97 ab	6.11 bc	6.49 b	14.98 b
T_2	1.20 bc	2.95 bc	5.50 bc	5.72 bc	5.70 c	7.51 ab	10.89 c
T_3	1.16 c	2.36 c	3.68 d	5.51 c	4.24 d	5.06 c	5.59 d
T_4	1.28 ab	3.53 ab	4.92 c	5.89 abc	6.28 bc	6.65 b	15.32 b
T_5	1.29 ab	3.35 abc	6.03 ab	6.14 ab	6.60 b	8.29 a	18.03 a
T_6	1.30 a	4.49 a	6.61 a	6.26 a	7.61 a	8.64 a	18.91 a
$LSD_{(0.05)}$	0.094	1.060	0.664	0.387	0.676	1.221	2.360
CV(%)	4.90	11.35	8.96	4.41	7.97	12.76	10.71

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.8 Number of pulse beetle larvae under storage condition

Statistically significant variation was recorded for number of larvae in seeds at different days after storage (DAS) of seeds collected from plots of different dates of sowing (Appendix VII). At 30, 40, 50, 60, 70, 80 and 90 DAS the minimum number of larvae in seeds (3.00, 6.33, 8.00, 8.33, 9.67, 12.67 and 11.37) was recorded from seeds of T_3 treatment. On the other hand, the maximum number of larvae in seeds (8.33, 13.00, 14.67, 16.67, 19.00, 22.33 and 27.78) was recorded from seeds of T_6 treatment (Table 5).

4.9 Number of pulse beetle pupae under storage

Number of pupae in seeds at different days after storage (DAS) showed statistically significant differences for seeds collected from plots of different dates of sowing (Appendix VIII). At 30, 40, 50, 60, 70, 80 and 90 DAS the minimum number of pupae in seeds (3.44, 7.51, 9.07, 11.49, 15.64, 18.35 and 24.08) was recorded from the seeds of T_3 treatment and the maximum number of pupae in seeds (4.79, 10.32, 13.05, 16.30, 19.90, 24.02 and 30.85) was recorded from seeds of T_6 treatment (Table 6).

4.10 Number of pulse beetle adult under storage

Statistically significant variation was recorded for number of adult in seeds at different days after storage (DAS) for seeds collected from plots of different dates of sowing (Appendix VIII). At 30, 40, 50, 60, 70, 80 and 90 DAS the minimum number of adult in seeds (1.16, 2.36, 3.68, 5.51, 4.24, 5.06 and 5.69) was recorded from the seeds of T_3 treatment, while the maximum number of adults in seeds

(1.30, 4.49, 6.61, 6.26, 7.61, 8.64 and 18.91) was recorded from those of T_6 treatment (Table 7)

Table 8. Effect of different dates of sowing on the seed infestation pulse beetle under storage condition

Treatment	%Infestation of seed under storage condition at						
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
T_1	7.56 c	8.44 e	9.11 e	9.78 de	10.22 d	11.56 c	12.89 cd
T_2	8.22 c	9.78 d	10.44 d	10.89 d	11.78 c	12.44c	14.22 c
T_3	5.56 d	5.78 f	7.56 f	8.67 e	9.78 d	10.22 d	12.22 d
T_4	10.67 b	12.22 c	13.56 c	15.33 c	17.33 b	18.44 b	20.67 b
T_5	14.67 a	15.33 b	16.00 b	17.11 b	18.22 b	18.67 b	22.44 a
T_6	16.00 a	16.67 a	18.67 a	19.33 a	20.67 a	21.33 a	23.78 a
$LSD_{(0.05)}$	1.417	1.246	1.107	1.165	1.193	1.107	1.359
CV(%)	7.46	6.02	4.85	4.74	4.47	3.94	4.22

T_1: Sowing on 15 November' 07

T_2: Sowing on 25 November' 07

T_3: Sowing on 5 December 07

T_4: Sowing on 15 December' 07

T_5: Sowing on 25 December' 07

T_6: Sowing on 4 January' 08

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatment

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

CHAPTER V

SUMMARY AND CONCLUSION

The study was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November, 2007 to July, 2008 to find out the effect of dates of sowing on the incidence of chickpea pod borer in field and pulse beetle in storage. . The experiment consists of 6 treatments VIZ, T_1: sowing on 15 November, 07; T_2: sowing on 25 November, 07; T_3: sowing on 5 December, 07; T_4: sowing on 15 December, 07; T_5: sowing on 25 December, 07 and T_6: sowing on 4 January, 08..

The field experiment was laid out in Randomized Complete Block Design and laboratory experiment was laid out in Complete Block Design respectively. Data on number and weight of healthy pod, infested pod and pod infestation by number and weight, average infestation by number and weight, yield contributing characters and yield, seed infestation in storage were recorded.

At early fruiting stage the lowest pod infestation per plant in number (4.90%) was recorded from T_3 treatment again, the highest pod infestation per plant (14.21%) was recorded from T_6 treatment. At mid fruiting stage the lowest pod infestation per plant in number (5.88%) was recorded from T_3 and, the highest (16.20%) was recorded from T_6. At late fruiting stage the lowest pod infestation per plant by number (8.18%) was recorded from T_1 and the highest pod infestation per plant (17.08%) was recorded from T_6. The lowest average pod infestation per plant by

number (6.62%) was recorded from T_3 and the highest (15.83%) was recorded from T_6.

At early fruiting stage the minimum pod infestation per plant by weight (6.01%) was recorded from T_3 and the maximum pod infestation per plant (15.57%) was recorded from T_6. At mid fruiting stage the minimum pod infestation per plant by weight (6.37%) was recorded from T_3 and the maximum pod infestation per plant (17.22%) was recorded from T_6. At late fruiting stage the minimum pod infestation per plant in weight (8.70%) was recorded from T_1 and the maximum pod infestation per plant (18.02%) was recorded from T_6 . The minimum average pod infestation per plant by weight (7.35%) was recorded from T_1 and the maximum pod infestation per plant (16.94%) was recorded from T_6.

The longest plant (87.83 cm) was recorded from T_3 and shortest plant (80.40 cm) was recorded from T_1. The highest number of branches per plant (4.93) was recorded from T_3 and the lowest number of branches per plant (4.07) was recorded in T_6. The highest number of leaves per plant (42.40) was recorded from T_3 and the lowest number of leaves per plant (35.93) was recorded in T_1. The highest number of pods per plant (66.63) was recorded from T_6 and the lowest number of pods per plant (56.50) was recorded in T_1. The maximum pod length (4.72 cm) was recorded from T_3 treatment and the minimum pod length (4.22 cm) was recorded in T_6. The highest number of seeds per pods (4.52) was recorded from T_3 and the lowest number of seeds per pods (3.72) was recorded in T_6. The maximum weight of 100 seeds (137.07 g) was recorded from T_3 and the minimum

weight of 100 seeds (113.17 g) was recorded in T_6. The highest yield (1.32 ton/ha) was recorded from T_3 and the lowest yield (1.20 ton/ha) was recorded in T_6.

At 30, 40, 50, 60, 70, 80 and 90 DAS the lowest seed infestation by number (5.56%, 5.78%, 7.56%, 8.67%, and 9.78%) was recorded from T_3. On the other hand, the highest seed infestation by number (16.00%, 16.67%, 18.67%, 19.33%, 20.67%, 21.33% and 23.78 %%) was recorded from T_6. So, it may be concluded that the December is the suitable time for sowing chickpea by which the severe infestation of chickpea pod borer and pulse beetle could be avoided for gaining maximum yield.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability;
2. Another sowing date may be included in the future study;
3. Management practices and fertilizers may be included for further study.

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APPENDIX

Appendix I. Monthly average record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from November 2007 to February 2008

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
November, 2008	25.8	16.04	78	00	6.8
December, 2008	22.4	13.5	74	00	6.3
January, 2009	24.5	12.4	68	00	5.7
February, 2009	27.1	16.7	67	30	6.7

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix II. Analysis of variance of the data on incidence of chickpea pod borer at early, mid and late fruiting stage in terms of fruit per plant by number as influenced by different sowing dates

Source of variation	Degrees of freedom	Mean square									
		Early stage			Mid stage			Late stage			Averag infestat (%)
		Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	
Replication	2	0.272	0.011	2.835	0.191	0.044	0.261	2.167	0.047	0.147	0.375
Treatment	5	3.698*	3.079**	42.555**	12.943*	11.373**	50.385**	22.100*	14.902**	44.515**	45.025**
Error	10	1.069	0.040	1.274	2.621	0.187	0.856	4.767	0.076	0.565	0.489

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix III. Analysis of variance of the data on incidence of chickpea pod borer at early, mid and late fruiting stage in terms of fruit per plant by weight as influenced by different sowing dates

Source of variation	Degrees of freedom	Mean square									
		Early stage			Mid stage			Late stage			Average infestation (%)
		Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	Healthy	Infested by pod borer	% infestation	
Replication	2	25.767	0.051	0.157	17.929	2.585	0.161	234.346	32.752	0.544	0.055
Treatment	5	295.811*	307.901**	46.254**	1217.8**	1228.9**	56.007**	2390.3**	1763.3**	47.22**	48.935**
Error	10	81.485	2.160	0.383	246.631	13.907	0.850	515.563	4.452	0.244	0.236

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on yield contributing characters and yield of chick pea as influenced by different sowing dates

Source of variation	Degrees of freedom	Mean square							
		Plant height at harvest (cm)	Number of branches per plant	Number of leaves per plant	Number of pods per plant	Pod length (cm)	Number of seeds per pod	Weight of 100 seeds (g)	Yield (t/ha)
Replication	2	0.842	0.121	0.961	0.375	0.060	0.004	4.156	0.003
Treatment	5	19.213*	0.386**	14.638**	36.894**	0.111*	0.274**	183.317**	0.007**
Error	10	5.113	0.045	1.814	2.944	0.024	0.029	15.662	0.001

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on seed infestation under storage condition of chick pea as influenced by different sowing dates

Source of variation	Degrees of freedom	Mean square						
		Infestation (%) at						
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS
Replication	2	0.963	0.025	0.963	0.173	0.222	0.074	0.173
Treatment	5	51.556**	52.114**	54.919**	56.677**	64.652**	63.274**	80.099**
Error	10	0.607	0.469	0.370	0.410	0.430	0.370	0.558

**: Significant at 0.01 level of probability;