# EVALUATION OF SOME CONTROL METHODS AND THEIR EFFECTIVENESSES AGAINST BEAN POD BORER, *MARUCA TESTULALIS* GEYER


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# CERTIFICATE

This is to certify that thesis entitled, "**EVALUATION OF SOME CONTROL METHODS AND THEIR EFFECTIVENESS AGAINST BEAN POD BORER, *Maruca testulalis Geyer*"** 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 (M. S.) IN ENTOMOLOGY,** embodies the result of a piece of *bona fide* research work carried out by TAHMINA AKTER Roll No. 01848 Registration No. 01848 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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



**Dated:**
**Place: Dhaka, Bangladesh**

**(Dr. Md. Serajul Islam Bhuiyan)**
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*December, 2006* — *The author*

## LIST OF ABBREVIATION

| Full word | Abbreviation |
|---|---|
| Agro-Ecological Zone | AEZ |
| And others | *et al.* |
| Bangladesh Bureau of Statistics | BBS |
| Centimeter | cm |
| Co-efficient of variation | CV |
| Days after transplanting | DAT |
| Degree Celsius | $^{0}C$ |
| Degrees of freedom | d.f. |
| Et cetera | etc. |
| Emulsifiable Concentrate | EC |
| Food and Agriculture Organization | FAO |
| Figure | Fig. |
| Gram | g |
| Hectare | ha |
| Hydrogen ion concentration | pH |
| Journal | J. |
| Kilogram | kg |
| Least significant difference | LSD |
| Liter | l |
| Meter | m |
| Mean sum square | MS |
| Millimeter | mm |
| Murate of Potash | MP |
| Number | no. |
| Percent | % |
| Randomized Complete Block Design | RCBD |
| Sher-e-Bangla Agricultural University | SAU |
| Serial number | SL. NO. |
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# EVALUATION OF SOME CONTROL METHODS AND THEIR EFFECTIVENESSES AGAINST BEAN POD BORER, *MARUCA TESTULALIS* GEYER

**BY**
**TAHMINA AKTER**

## ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from September 2006 to March 2007 to evaluate some control methods and their effectiveness against bean pod borer, *Maruca testulalis* Geyer. The experiment consists of treatment such as mechanical, one botanical and one chemical and their combinations. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected in respect of the fruit infested in number and weight basis and some yield contributing characters and yield of bean. Data on percent infested fruit in terms of number and weight per plot showed statistically significant variation at 0.01 level of probability. In early, mid and late fruiting stage the highest percent infested fruit in number and weight was recorded in untreated plot and the lowest was found in the plot treated with mechanical control plus Ripcord 10EC @ 2m/l of water at 7 days interval for all the harvest. In number of flower inflorescence (18.33) was recorded in $T_5$ (mechanical control plus Ripcord 10EC @ 2m/l of water at 7 days interval) treatment and the lowest number of flower inflorescence (13.37) was recorded in $T_7$ (untreated control) treatment. The highest weight of single fruit (11.80 g) was recorded in $T_5$ (mechanical control plus Ripcord 10EC @ 2m/l of water at 7 days interval) treatment and the lowest weight of single fruit (8.83g) was recorded in $T_7$ (untreated control) treatment. Maximum and minimum length of single fruit (11.90cm) was recorded in $T_5$ (mechanical control plus Ripcord 10EC @ 2m/l of water at 7 days interval) treatment and in $T_7$ (untreated control) treatment (9.83cm) respectively. The highest yield per hectare (17.65 ton) was recorded in $T_5$ treatment and the lowest (9.93 ton) was recorded in $T_7$ (untreated control) treatment. On the other hand highest benefit cost-ratio (2.89) was recorded in the treatment $T_5$ and negative benefit cost-ratio (-0.51) was recorded in treatment $T_1$.

# Chapter I

# INTRODUCTION



The country bean *Lablab purpureus* Limnaeus is a delicious vegetable crop in Bangladesh. It belongs to the leguminosae family (Thompson, 1951). It is a rich source of essential vitamins and commonly grown during rainy through rabi seasons usually around the homestead by trailing its vine either on trees or by providing different kinds of supports. Although beans are considered as the major group of vegetables grown intensively in rabi seasons, some varieties of country bean can be grown year round including kharif seasons. The importance of country bean is thus highly significance from growing season point of view. Because of this reasons less than 30% of the vegetables are produced in kharif season and more than 70% are in the rabi season (Hossain and Awrangzeb, 1992).

Bangladesh has a deficiency in vegetables with an annual production of only 2.5 million tons including potato and sweet potato (Anon., 1993). This production is too low to fulfill the nutritional requirements of the people. At present average per capita daily consumption of vegetables in Bangladesh in 26 gm as against the reported requirement of balanced nutrition of vegetables is 200gm per capita (Haque, 1991). At this rate, annual requirement of vegetables is about 5.48 million tons. In order to lessen the shortage attempt is needed to increase the country bean production. In this situation, the country bean having varieties suitable for production during off season can play a vital role to meet up the off season deficiency of vegetable.

The country bean is as known as Hyacinth bean, Lablab bean, Indian bean, Kidny bean, Lima bean, Seam bean etc (Rashid, 1999; Purseglove, 1977). It is cultivated in homestead areas, main land or in the border of plot (ails) of cropland. For bean cultivation high land should be selected to avoid water logging. It is grown almost in all districts of Bangladesh. Its concentration is found in Dhaka, Jessore, Comilla, Noakhali and Chittagong but for the last ten years country bean have been seen growing extensively in Jessore, Khulna, Chittagong region as well (Adity, 1993). Tremendous development in country bean cultivation as ail crop is striking the attention of the general people of Chittagong region (Rashid, 1983; Aditya, 1993)

The major vegetables grown in rabi season are different kind of beans which appear as one of the most important group of vegetables in our daily food. Its young pods and unripe seeds are used as vegetables, dry seeds are as pulse and the biomass after the harvest is used as fodder. The green pods contain 4.5% protein (Rashid, 1996). The green pods and dry seeds are also fairly rich in calcium and vitamin C (Grubeen, 1997)

In spite of being a prospective crop, high incidences of insect pests have, limited the crop into its low yield and poor quality. Farmers in our country faced various problems including the availability of quality seeds, fertilizer and manures, irrigation facilities, modern information in the fields of technical and instrumental inputs, pests and disease in cultivation of the corp. (Rashid, 1993), Among these, insect pests are the most important and cause enormous quantity of yield losses in every season and every year. Although no regular statistical records are kept, as per conservative estimate the yield loss in country bean due to insect pests is reported to be about 12-30% (Hossain, 1990). According to Alam (1969), country bean is attacked by nine different insect species and one species of mite. Among these species, four species are considered as major pests and the rest of them as minor pest. A FAO panel meeting held in Bangkok in 1975, identified the bean pod borer, *Maruca testulalies* G. as a legume pod borer (Reddy, 1975). Dina (1979) and Baker *et.al.*(1980) found *Maruca testulalis* G (Lepidoptera: pyralidae), is a serious insect pest of leguminous vegetables, Butani and Jotwani (1984) found that Lepidopterous larvae *Maruca testulalis* (Geyer) as pests of bean causing damage by boring tender or mature pods. Bean pod borer is able to establish itself on legumes from vegetative to reproductive stage. At the early stage of plant growth, the bean pod borer, attack the crop making clusters of leaves, tendrils and young shoots of the plant. Later at flowering and pod setting stages of plants, the insect bore into these reproductive organs, where the insect feeds internally (Taylor, 1967; Singh, 1983; Das and Islam, 1985; Rahman, 1989; Karim, 1993; Begum, 1993; Sharma, 1998).

A survey on pesticide use in vegetables conducted in 1988 revealed that only about 15% to16% of the farmers received information from the pesticide dealers and extension agents respectively (Islam, 1999). In most of the cases, the farmers either forgot the instructions or did not care to follow those instructions and went on using insecticides at their own choice or experience. Some farmers believed that excess use of insecticide could solve the insect pests problem. They did not follow the rule of economic threshold and economic injury level. They usually spray insecticide in their field indiscriminately even without thinking the economic return of their investment. As a result, harmful impact of insecticides on man, animal, wild life, beneficial insects and environment is imposing a serious threat. Indiscriminate uses of insecticides are reported to cause insecticide resistance in insect, pests resurgence and secondary pests out break. The accumulation of insecticide residues in food is increasing at an alarming rate. So there is a chance of human health hazards due to these detrimental toxicants.

Begum (1993) found that the management of insect pests of country bean required 2-3 times spray. Malathion, Nogos Sumithion and Ripcord should be used @ 1 % at flowering stages or when pod infestation exceeded 10%. But the farmers, in general, do not follow such need based practice, in this situation for vegetable corps, like country beans, which are harvested and consumed as young pods, the use of integration of some control methods or IPM is more desirable, because the time between insecticide application and harvest of young pods may not be enough for break down and detoxification of the applied insecticides.

There are several pest control methods for controlling bean pod borer, as like cultural (Amoake – Atta *et al.*, 1983; Ezuch and Taylor, 1984; Fisher *et al.*, 1987; sharma, 1998), natural and applied biological (Usua and Singh, 1978; Karim, 1995) and chemical control measures (Rahman and Rahman, 1988, Begum, 1993; Karim, 1993 and 1995). Although different methods of controlling the pest are available, growers in Bangladesh, however, frequently use chemical insecticides in order to protect country beans from damages due to pod borer attacks (Rahman, 1989; Begum, 1993; Karim, 1992 and 1995). Since, Bean pod borers, *Maruca testulalis* frequently feed internally on infested plant parts while living inside the clusters or pods, insecticide applications, particularly a single application, may often fail to provide successful control of the pest (Begum, 1993; Rahman, 1989). As a result, multiple applications of insecticides are required for controlling this pest. Neem oil is very new and unexploited approach in this context. Therefore, the present study was under taken to test this approach with or without chemical applied alone or in combination, Besides a selected insecticide and or botanical was tested individually or in packages and evaluated their performance in combating this pest with economic analysis.

Accordingly the present study was under taken for the following objectives:

- To determine the effectiveness of chemical and non-chemical control methods and their combination against bean pod borer, *Maruca testulalis.*

- To evaluate the of combined effect of chemical, non-chemical techniques in controlling this pest.

- To analyze the benefit cost ratio of treatments integrated with or without chemical.

# Chapter II

## REVIEW OF LITERATURE

Bean pod borer, *Maruca teslulatis* is considered as an important and most damaging pest of country bean. Substantial works have been done regarding its geographical distribution, host range, seasonal abundance, population dynamics, its infestation intensity, loses incurred by them, existing IPM practices etc., at home and abroad. An effort has been made to review the available literatures, Although the review could not be made so comprehensive due to limited scope and facility, it is hoped that most of the relevant information available in and around Bangladesh could be collected and reviewed, However, these studies are reviewed below under the following sub-heading covering the aforesaid areas.

### Origin and distribution of bean pod borer

The Bean pod borer, *Maruca testulalis* has been considered as serious pest of grain legumes in the tropics and sub-tropics, because of its extensive host rang, destructiveness and more wide distribution (Taylor, 1967; Raheja, 1974). With continuous changes in global environment, its floral and faunal compositions, the insect may spread further in places beyond its known distribution.

### Host range of bean pod borer

Bean pod borer, *Maruca testulalis,* is a polyphagous insect, which have been reported to feed on various types of plants, both cultivated and wild. Akinfenwa (1975), and Atachi and Djihou (1994) reported that the insect has been observed to feed on 39 host plants; most of these plants were leguminous. Among the host plants, the most frequent ones are Cajanus *cajan, Vigna unguiculata, Phaselus lunatus* and *Pueraria phaseoloids.* In Asia, it is an important pest of pigeon peas, common beans, soybean, red gram and cowpeas (Singh and Jackel, 1988). Babu (1989) found hyacinth bean was the most favourable food plant for *Maruca testulalis* G. including Bangladesh. *Maruca testulalis is* a tropical insect attacking several species of food begums in Asia, Africa, Central America, and South America. The insect has been reported to consume and survive well on pigeon pea, cowpea and hyacinth beans

(Ramasubramanian and sumdara Babu, 1988; Ramasubramanian and Samdara Babu, 1989a) In absence of the preferred hosts, the insect would perpetuate on alternate and wild hosts such as *Vigna tribola, Crotularia* spp., *Phaseolus* spp. and pigeon peas (Tarylor, 1967).

**Biology and life history strategies**

Adults are small, dark gray in color with white brown patterns of the wings. The color patterns can be more conspicuous on the fore wings, with a silvery white brown spat at the apical margin, than on the mind wings, the females have brownish abdomen with bifid hairy ovipositors. After emergence from the pupae, adult males and females mate, which may sometimes take place until the early morning, some males would mate more than once, although females usually mate once (Jackai *et al.*, 1990). But some males may not be successful in finding females.

Usually a female moth oviposits up to 400 eggs during her lifetime (Okeyo-owuor and Ochieng, 1981). The eggs are normally deposited on the under surface of plant parts (Vishakntaiah an Babu, 1980; Rai, 1983).

The eggs are white in color, which become translucent later. The eggs are oval, dorsoventrally flattened and have faint reticulate sculpturing on the delicate chorion (Okeyon-Owuor and ochieng, 1981).

The mean incubation period is 3 days under at around 25-28°C and over 80% relative humidity (Vishakantiah and Babu, 1980; Okeyo-Owuorand ochieng, 1981; Rai, 1983).

After hatching the first instar larvae move on the surface of leaves, flower buds and flower for few minutes before starting feeding. A larva has to pass through 5 (five) instars before moulting into a pupa. The larvae are creamy white in colour with dark brown head and prothoracic shield. At the early stage the body of larvae bears light spots become turn into dark sports at the fifth instar, which are distinctly visible. A larva at the fifth instar feeds voraciously on flower buds, flowers and pods (Rai, 1983) The total larval period is 10-14 days. Differences in weather conditions, particularly the humidity in different regions might also have caused variations in duration of this larval period.

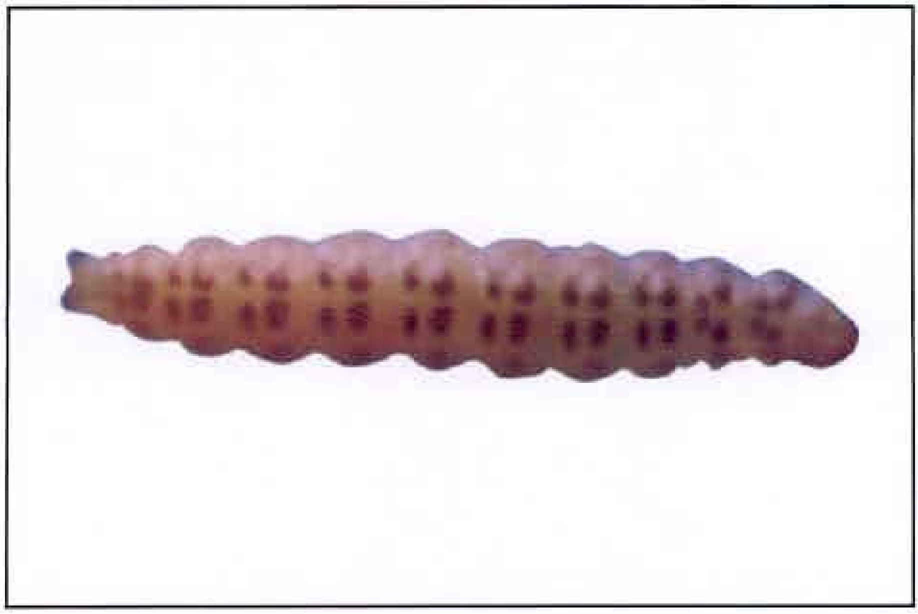

**Plate: 1 Larva of bean pod borer**

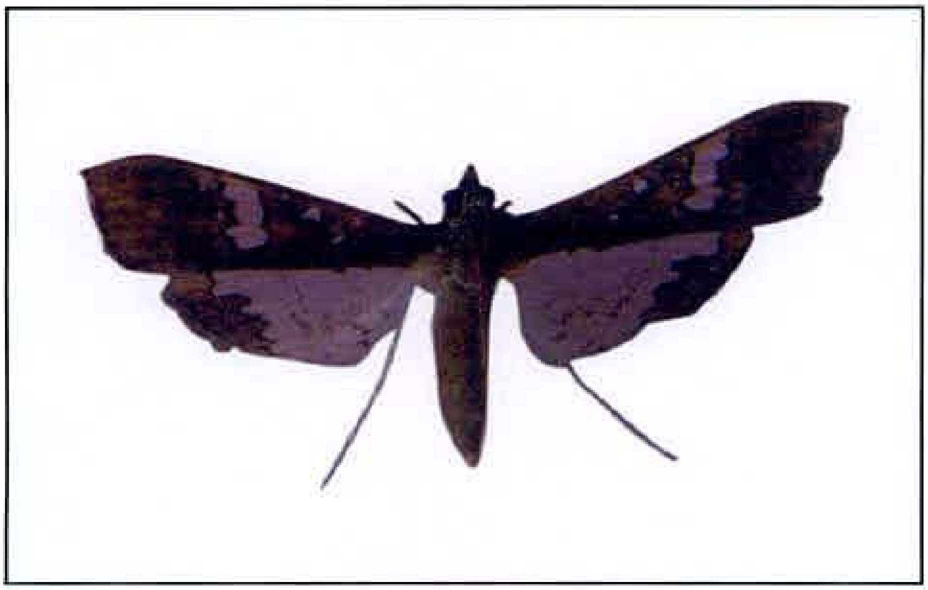

**Plate: 2 Adult of bean pod borer**

The fifth instars larva stops feedings and the body shrunk before entering into the pupal stage. To pupate, the larva spins silken threads around it in a net fashion and moult into a pupa within the silken cocoon covered under dried leaves on soil. The pupa is reddish brown in color. The lower development threshold temperature for pupae is 15.6 - 17.8$^{o}$ C and the upper threshold in 28$^{o}$C to 34$^{o}$C (Sharma, 1998). The pupal period on average is 9 days.

The female moths have been found to live 11 or 12 days, whereas the males live 9 or 10 days at around 28$^{o}$ C Singh, 1983).

**Seasonal abundance**

In general, the insect population fluctuates from month to month, season to season, even year to year. Information about seasonal abundance of bean pod borer is scanty. According to Sharma (1998), *Maruca* pod borer population build up is related to cumulative rainfall and the number of rainy days between crop emergence to flowing and the insect have two overlapping generations in a year in most places of its distribution. According to Saxena *et al.* (1992) the insect population of bean pod borer larvae was occurring in their peak levels of bean pod during the beginning of the second week of January to the first week of February. And the insect larvae were in their peak presence in flowers around the middle of December, after which the population declined in flowers in Sri Lanka.A high larval density of *Maruca testulalis* in host corps planted in Mid-October.

In Bihar of India, Akhauri *et al.*, (1994) observed that in early pigeon pea the larval density increased from mid-October to the end of November, with the occurrence of peak larval density in the last week of November.

**Nature of damage of bean pod borer in country bean**

*Maruca testulalis* G. is a very important pest causing serious damages to the country beans in Bangladesh. Toylor (1978) reported Bean pod borer (*Maruca testulalies* G.)

As a pest of tropical grain legumes. *Maruca* cause damage in pigeon pea both by boring into the flower and pod as well as by webbing flowers, pods and leaves to form clusters (Rahman, 1989). Babu (1989) found hyacinth bean was the most favorable food plant for *M. testulalis* G. Including Bangladesh, *Maruca testulalis* (Geyer) is a tropical insect attacking several species of food legumes in Asia, Africa, Central America, and South America. In Asia, it is an important pest of pigeon peas, common beans, soybean, red gram and cowpeas (Singh and Jackal, 1988). It damages buds, flowers and pods, which severely affect grain yield (Singh and Taylor, 1978). At flowering stage, the larvae entered into the flower buds and flowers. The attacked buds and flowers subsequently withered. In a seriously infested field, large numbers of infested flower buds and flowers were often encountered. With the onset of pod formation, the insect larvae started attacking the pods. The infested flower buds, flower and pods were found webbed together (Karim, 1993). The first and second instars larvae fed mostly on the inner walls of the young pods by scrapping. The larvae of later instars, in most cases, entered into the pods, bored the seed and fed on the seeds by making circular holes; but the holes were often plugged with excreta. Occasionally they consumed the entire seed. They also burrow into flower buds and hollow them out. Some times leaves are spun together and caterpillars feed within the web (Das and Islam, 1985; Singh, 1983). A developing larva after entering into a pod usually did not leave it until its food was totally exhausted. The infested pod often became unfit for human consumption. However, under natural conditions larval feeding punctures were found on some pods. But no larva finally developed in them. In most of the field collected infested pods only one larva was found/ pod, while there were two larvae/pod in only a few cases (Das and Islam, .1985). Pyralid pod borer, *Maruca testulalis,* is an important pest, which attacks pods, and extruded frass is usually a rather obvious indicator of such damage (Emden, 1980).

**Yield Loss in Country bean due to Bean pod Borers**

Bean pod borer is every important pest of the country bean. In recent study, *Maruca testulalis* G was found to cause maximum damage in pigeon pea in Bangladesh (Rahman, 1987). As an important pest of leguminous vegetables, substantial works have been done on *Maruca testulalis* G. The susceptibility of country bean genotype to pod borer, *Maruca testulalis* G., was studied at the Regional Agricultural Research Station, Jamalpur. Out of 32 genotypes, the highest percentage of infestation was found in Bata (Mirsharai) (16.81+ 1.21%), and the lowest percentage of infestation in sword bean (0.74 + 0.05%) (Kabir *et. al.*,1983). The bean pod borers were found to cause 38% yield loss through flower and pod damage and have been reported as the most important pests of pigeon pea in Bangladesh (Rahman *et al,* 1981). Bean pod borer is considered as a major pest of legumes in Africa, Asia, South and Central America and Austrilia causing yield loss ranging between 20% and 60%. When dimethoate applied the highest (78%) flower damage by *M. testulalis* G. and grain yield of 684 kg /ha was achieved. But when applied methomy flower damage was 6.2 and grain yield was 1240 kg /ha as against 80.1% flower damage and 102 kg /ha grain yield in control (Singh and Allen, 1980) *Maruca testulalis G.* in one of the important insect pests of French bean. Studies at the Sokoine Univeristy of agriculture (Morogoro, Tanzania) have indicated that uncontrolled populations of pod bores, particularly *M.testulalis,* decreased the seed yield by 20-50% in some local cultivars (Karel, 1985). In Kenya, studies have revealed that *Maruca testulalis G.* is the most important pest of cowpea, reducing yields by up to 80% (Okeyo-Owuor andOchieng, 1981).

## Management of Bean pod Borer

### Non-chemical control

Farmers believe that insecticides are the only method to control insect pest, This mental make up has been created from their practice of using insecticides to control the insect pests attacking their crops over many years (Islam, 1999). More over, the Government's policy of giving 100% subsidy on pesticides i.e., giving the pesticides free of cost to the farmers had helped encourage and develop the habit of indiscriminate use of pesticides among the farmers. This is serious basic problem in achieving success in IPM programs.

The populations of *Maruca testulalis* G. were fluctuated with agro meteorological factors, the distribution of rainfall over time is more crucial than the total amount in determining the fluctuations of pod borer populations. Thus, the adjustment of planting dates is suggested as an IPM tactic to avoid the development of damaging levels of pod borer infestations (Alghali, 1993)

## Use of Neem oil

Neem *(Azadicachat Indica A. Juss)* seed oil, a botanical pesticide have also been used to control different insect pests of important agricultural crops in different countries of the world. More than 2000 species of plants have been reported to possess insecticidal properties (Grainge and Ahmed, 1988). The neem tree is one of them. The development and use of botanical pesticides become an integral part of the integrated pest management (IPM) strategies. Stoll (1992) summarized the potential benefits of botanical pesticides which diminish the risk of resistance development, natural enemy elimination, secondary out break of pest and ensure overall safety to the environment.

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

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

Ahmed and Grainge (1985) and Saxena (1988) summarized the effectiveness of neem oil against 87 arthropods and 5 nematodes, 100 insects and mites and 198 different species of insects, respectively.

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

Field trail with neem products have shown, not only a decrease in damage by pest but also an increase in crop yield compared to those obtained with recommended synthetic insecticides. A methanol suspension of 2-4% of the neem leaves have been used against the caterpillar of diamondback moth, *Plutella xylostella* and it was as effective as either synthetic insecticides mevinphous (0.05%) or deltamethrin in (0.02%) in Togo (Dreyer, 1987). In Thailand, a field trail showed that piperanyl butoxide increased the efficacy of neem and the combination was as active as cypermethrin (0.025%) against *Plutella xylostella* and *Spodoptera litura,* which revealed that neem oil with synthetic insecticides may have some synergetic effect in controlling insect pests (Sombatsiri and Tigvattanont, 1987). Fagoonee (1986) used neem in vegetable crop protection in Mauritius and showed neem seed kernel extract was found to be effective as deltamethrin (Decis) against the *Plutella xylostella* and *Crocidolomia binotalis.* He also found neem extract alternate with insecticides gave best protection against *Helicovarpa armigera.* Neem product have been used to control vegetable pests under field condition and good control of *Plutella xylostella* and Pyralid, *Hellula undalis* on cabbage was achieved with weekly application of 25 or 50 gm neem kernel powder/liter of water (Dreyer, 1986). The leaf extract of neem tested against the leaf caterpillar of brinjal, *Selepa docilis* Bult. at 5% concentration had a high antifeedant activity with a feeding ratio of 28.29 followed by 3% having only medium antifeedant properties with 23.89 as the feeding ratio (Jacob and Sheila, 1994).

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

Most of the cases, the user of neem oil use it at different doses ranged from 0.5-50% (Krishnaiah and Kalode, 1991). They use different emulsifier to mixe neem oil with the water. Neem oil normally stays separately on the upper surface of the water. Detergent in water helps neem oil to emulsify in the water. In a field observation of neem oil Krishanaiah and Kalode (1991) used soap as emulsifier with water although they have never mentioned the dose of the emulsifier in their trail. Another study with neem oil in rice field, Palanginan and Saxena (1991) added 1.66% Teepol (liquid detergent) to the extract solutions as an emulsifier. In a study of Bangladesh Rice Research Institute (BRRI), Gazipur, Alam (1991) added 1 ml (0.1%) of teepol detergent per liter of water and spray at 7 days interval against stem borer of rice.

**Biological control against bean pod borer**

The role of natural enemies ore reducing the insect population of *Maruca testulalis* was significant. The populations of *Maruca testulalis* G. were fluctuated with agro meteorological factors. The distribution of rainfall over time is more crucial than the total amount in determining the fluctuations of pod borer populations. Thus, the adjustment of planting dates is suggested as an IPM tactic to avoid the development of damaging levels of pod borer infestations (Alghali, 1993). Neem oil, Neem oil emulsifiable concentrate, Neem oil slurry emulsifiable Colicefitrtte and 5% neem oil emulsifiable concentrate from the seeds of the neem plant, were tested against *Maruca testulalis* G. under laboratory condition (Jackai and Oyediran, 1991). The role of natural enemies on reducing population was significant. Parasitoids cause death by their stinging activity during host selection and some parasitized larvae and pupae carcasses decayed in the soil. Diseases and parasitism alone contributed significantly to the total generation mortality. These factors contributed significantly to the low survivability obscurest in the field (Okeyo-Owuor *et al,* 1991). It was found that *M. testulalis* was attacked by a rich fauna of parasitoids, pathogens and predators. Seven parasitoids were observed to attack larvae and pupae of the Bean pod borer but no egg parasitoids were found. Large number of parasitoids has been reported to feed on Maruca larvae and some on pupae (Waterhouse and Norris 1987). Don Pedro (1983) found *Phanerotoma* sp. and *Braunsia* sp. to be the most important parasitoids in Nigeria. Some pathogenic microorganisms were isolated from dead *M. testulalis* larvae and pupae, among these Protozoa, *Nosema sp* and the bacteria, *Bacillius sp.* were the most common (Okeyo-Owuor *et al.,* 1991). One parasitoid, namely, *Bracon greeni* was reared from the field collected pest larvae. Usua and Singh (1978) recorded some other parasitoids of *M. testulalis* without any reference of *Bracon greeni.* From each of the parasitized larvae 3-8 parasitoids emerged. Control of *Maruca testulalis* by microbial insecticide *Bacillus thuringiensis* and aqueous extracts of neem seed kernel powder (25- 50 g neem kernel powder /l of water) starting from flowering was very effective (Karim, 1995). It was found that twice after flowering application treatments of microbial insecticide thuricide, dipel, and bactospene were as effective as fenvalerate and deltamethrin to reduce numbers *of Maruca larvae* and flower damage (Supriyatin,1990). Oghiake, *et al.,* (1993) observed antibiosis of 18 cowpea cultivars resistance against *Maruca testulalis* G. Such resistance with morphological, biochemical and biophysical traits, could enhance the low levels of resistance in cowpea crop and ultimately lead to the effective management of the pest. *Nosema marucae* (Microspora: Nosematidae) is a pathogen of *Maruca testulalis* G. The development of *Nosema marucae* was followed in its host, the legume pod borer (Odindo and Jura, 1992). Preliminary studies were reported on the population of the legume pod borer *Maruca testulalis* G. using a pheromone trap at Mbita, Kenya

(Okeyo-Owuor and Agwaro, 1982). The female *Maruca testulalis* moths produce a pheromone product, which attracts males from the field at night.

Proper management of the crop fields so that conservation and augmentation of these agents are optimized might further enhances the reduction of the pest population through biological control agents.

**Control with chemical insecticide**

A number of reports revealed that a hundred of insecticides are used against bean pod borer. Most of the cases the farmers reduced their spray interval. A report showed that the vegetable growers of Jessore region of Bangladesh spayed insecticides almost every day or every alternate day in their bean field (Anonymous, 1994). Some of the farmers spray insecticides in their vegetable field even 84 times in one season. Majority of the farmers were found to sell their produce harvested residues with bean that causes health hazards to the consumers.

Search of review reveals that bean pod borer control is dominated by chemical approaches. In India, a number of insecticides have been evaluated for the control of pod borer in pulses including pigeon pea (Rahman, 1989). But no such trial has so far been conducted on country bean in Bangladesh. Several commonly used insecticides such as endosulfan, carbaryl, methomyl, monocrotophos have been found effective against *Maruca testulalis* G. on cowpea (Singh, 1977; Lalasangi, 1988). Cypermethrin was sprayed at 0.2 kg a.i./ha to control different densities of pyralid *M. testulalis* larvae when infestation in flowers reached 10, 20, 30, 40 and 50% in 1985 and 10; 20 and 30% in 1986 (Ogunwolu, 1990). Four sprays of 0.08% cypermethrin (at flowering, at 50 and 100% flowering and at 100% pod setting) afforded complete protection against *Maruca testulalis* on pigeon pea in Bangladesh in winter season of 1987-88. But dimethoate was not as effective as cypermethrin (Rahman and Rahman, 1988). A schedule of insecticide sprays using decis (Deltamethrin) and systoate (Dimethoate) on 35, 45, 55 and 65 days after planting was investigated in Benin in 1985 to determine the most effective treatment against the pyralid *M. testulalis* on cow pea (Atachi and Sourokou, 1989). Broadley (1977) obtained control of *M. testulalis* with methomyl when applied at 337-450g (a.i.)/ha. Because of hidden nature of larval and pupal stages of the pest, it is difficult to control Maruca pod borer by chemical or other conventional means. Application of deltamethrin, cypermethrin or fenvalerate @ 0.008% or dimethoate, fenitrothrin, malathion, quinalphos or monocrotophos @ 0.008% or endosulfan 0.10% one at flowering and then at pod setting stage would be highly effective. However, at lower infestation, insecticide application would not be economically advisable (Rahman, 1989). Application of deltamethrin, cypermethrin or fenvalerate or cyfluthrin (Bethroid 0.50 EC) at the rate of 1.0 ml / 1 of water may be helpful for the control of the bean pod borer (Karim, 1995). Dandale *et al.* (1984) reported the superiority of cypermethrin, fenvalerate and endosulfan in reducing pod borer infestation in red gram. Spraying of synthetic pyrethroid insecticides at the rate of 1 ml per liter of water has been recommended for the control of the pest (Karim, 1993). Among the various control measures so far been reported for the management of the bean pod borer, chemical control appeared as comparatively effective and predominant one.

# Chapter III

## MATERIALS AND METHODS

The present study on the evaluation and effectiveness of chemical and non-chemical control methods for the reduction of bean pod borer, *Maruca testulalaris*, infestation *on* bean plant was undertaken. Neem oil, removal of infested flower and fruits and chemical insecticide along with an untreated control and some of their integrations were utilized in this study and conducted at the Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during September, 2005 to March 2007.The farm situated at $23^0 46'$ N latitude and $23^0 46'$ N longitude $90^0 23'$E with an elevation of 8.45 meter the sea level. Laboratory studies were done in the laboratory of Entomology department, Sher-e-Bangla Agricultural University. Required materials and methodology are described below under the following sub-heading.

### Climate and soil

**Climate:**

The experimental area is characterized by subtropical rainfall during the month of May to September (Annon., 1988) and scattered rainfall during the rest of the year (Appendix-I).

**Soil:**

Soil of the study site was silty clayloam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with PH 5.8-6.5, CEC-25.58 (Haider *et al.,* 1991).(Appendix-II)

### Land preparation:

The soil was well prepared and good tilth was ensured for commercial crop production. The target land was divided into 21 equal plots (2m ×2m) with plot to plot distance of 1m and block to block distance is1m. Each plot contains 4 pits (30cm × 30cm ×20cm), pit to pit distance is 1m. Standard dosages of cow-dung and fertilizers were applied as recommended by Rashid (1993) for country bean @ 12kg of cow-dung, 60gm urea, 100gm TSP and 100gm MP respectively per pit. Again 30gm urea was applied as top dressing after each flush of flowering and fruiting in three equal splits.

## Collection of seed, seedling raising and transplanting

The seeds of BARI seam-1 were collected from Bangladesh Agricultural Research Institute (BARI), for rapid and uniform germination the seeds of country bean were soaked for 12 hours in water. Seeds were then directly sown in the middle of September, 2006 in polyethylene bags (12cm × 18cm) containing a mixture of equal proportion well decomposed cowdung and loam soil. Seeds were sown in bags and irrigated regularly. After germination, the seedlings were sprayed with water by a hand sprayer. Water was sprayed once a day for one week. Seedlings were placed in a shady place and were transplanted on September $29^{th}$, 2006 in the pits of the experimental field after 15 days of germination. At the time of transplanting, polyethylene bag was cut and removed carefully in order to keep the soil intact with the root of the seedling.

## Cultural practices

After transplanting, a light irrigation was given. Subsequent irrigation was applied in all the plots as and when needed. After 7 days of transplanting a single healthy seedling with luxuriant growth per pit was allowed to grow discarding the others, propping of each plant by bamboo sticks (1.75m) was provided on about 1.5m high from ground level for additional support and to allow normal creeping. At initial vegetative and fruiting stage, bean aphids were found sporadically and were controlled by hand picking. Weeding and mulching in the plots were done, whenever necessary.

## Design of experiment

The experiment was laid out with seven treatments including one untreated control and replicated three time using Randomized Complete Block Design (RCBD).

Plate 5: Experimental field

Plate 6: Seedling in polythene bag

## Treatments

Comparative effectiveness of the following seven treatments in reducing the bean pod borer infestation on country bean was evaluated:

$T_1$ = Mechanical control comprising with clean cultivation, removal of infested flowers and fruits at 7 days interval.

$T_2$ = Neem oil @ 30 ml (3%) per liter of water at 7days interval .

$T_3$ = Ripcord 10EC @ 2 ml/1 of water at 7 days interval .

$T_4$ = ($T_1$ + $T_2$), Removal of the infested flowers, fruits and plant debris from the treated plots and spray neem oil @ 30 ml (3%) per liter of water at 7days interval.

$T_5$ = ($T_1$ + $T_3$), Removal of the infested flowers, fruits and plant debris from the treated plots and spray Ripcord10EC @ 2 ml/1 of water after 7 days interval .

$T_6$ = ($T_1$ + $T_2$+ $T_3$), Neem oil @ 30 ml (3%) per liter of water and Ripcord 10EC @ 2 ml/1 of water sprayed alternately at the7 days interval in addition to Mechanical control.

$T_7$ = Untreated control in bean plant without any control measures.

### Description of the treatments

$T_1$: Mechanical control: Mechanical control comprising bean plants with clean cultivation, removal of infested flowers and fruits. Plants under this treatment were grown from normal seedlings. Borer infested flowers and fruits were collected and destroyed. Clean cultivation was also practiced to keep the plot free from weeds and other debris to discourage pupation.

$T_2$ : Neem oil @ 3 ml/1 of water at 7 days interval. Under this treatment, neem oil were applied @ 30 ml (3%) per liter of water with trix liquid detergent @ 10 ml (1%) to make the oil easy soluble in water. After proper shaking the prepared spray was applied with a high volume knapsack sprayer at 7 days intervals commencing from first flowering.

$T_3$ : Ripcord 10EC @ 2 ml/1 of water at 7 days interval. For this treatment 2 ml of insecticide per liter of water was mixed and sprayed at 7 days intervals.

$T_4$ : Mechanical control plus neem oil @ 30 ml/1 of water should be applied. Under this treatment mechanical control comprising bean plants with clean cultivation, removal of infested flowers and fruits. Borer infested flowers and fruits were collected and destroyed. . Clean cultivation was practiced to keep the plot free from weeds and other debris to discourage pupation. This treatment also include the application of neem oil @ 30 ml (3%) per liter of water at 7 days intervals with trix, a liquid detergent @ 10 ml (1%) concentration.

$T_5$ : Mechanical control plus Ripcord 10EC @ 2 ml/1 of water was applied. Under this treatment mechanical control comprising bean plants with clean cultivation, removal of infested flowers and fruits. Borer infested flowers and fruits were collected and destroyed. Clean cultivation was practiced to keep the plot free from weeds and other debris to discourage pupation. This treatment also include the application of Ripcord 10EC @ 2 ml/1 of water at 7 days interval.

$T_6$ : ( $T1 + T_2 + T_3$ ), Mechanical control (T1) plus Neem oil @ 30 ml/1 of water ($T_3$) and Ripcord 10EC @ 2 ml/l of water at alternate manner at 7 days interval ($T_4$): Plants under this treatments were grown from normal seedlings. Here the borer infested flowers and fruits were collected and destroyed. Clean cultivation was practiced to keep the plot free from weeds and other debris to discourage pupation. This treatment was also include neem oil applied @ 30 ml (3%) per liter of water mixed with trix liquid detergent @ 10 ml (1%) concentration. In addition Ripcord @ 2ml per liter of water was sprayed alternately every after 7 days at each harvest by a high volume knapsack sprayer.

$T_7$ : Untreated control. This treatment comprising non grafted plants without applying any control measures against bean pod borer.

## Collection of neem oil, trix detergent and preparation for spraying

The fresh neem oil was collected from Chawkbazar, Dhaka and the trix liquid detergent was collected from the local market of Agargaon bazaar. All sprays were made according to the methods described earlier. For each neem oil application 90 ml neem oil (@ 30 ml/liter of water i.e., 3%) was mixed with 9 ml of trix detergent (@ 3 ml/liter of water i.e., 1%) per liter of water. The mixture within the spray machine was shacked well and sprayed on the upper and lower surfaces of the plants of the treatment until the drop runoff from the plant. Three liters spray material was required to spray in three plots of each replication.

The insecticide (Ripcord10EC) treated plots were also sprayed following the procedure described earlier. For each spray with Ripcord10EC 6 ml insecticide (@ 2 ml/liter of water) was required. The insecticide was sprayed on the treated plots following the same manner as indicated before. The same quantity of spray material was required to spray three plots of the target treatment. The benefit-cost ratio was calculated following Ali and Karim (1991).

## Data collection

The effectiveness of each treatment in reducing the bean pod borer infestation was evaluated on the basis of some pre-selected parameters. The following parameters were considered during data collection.

### Number of infested flower

Borer infested flowers at each harvest were counted and tagged. The data were also recorded on the number of infested flower removed instead of tagging. This operation was done at an interval of 7 days at each harvest during early, mid and late fruiting stage of the plant from whole plants of each plot.

**Number of healthy and infested fruits**

Data were collected on the number of healthy and infested fruits per plot harvested at early, mid and late fruiting stages of the crop and weighted separately per plot for each treatment from whole plants of each plot. Five harvests were done at early fruiting stage and 4 harvests at the mid fruiting stage and 3 harvests were made at late fruiting stage of the plant. Marketable fruits were harvested usually at 7 days interval.

## Calculation

**Percent flower infestation per inflorescence (bean pod borer):** Total number of flowers per inflorescence and number of infested flowers was counted.

$$\text{Flower infestation (\%)} = \frac{\text{Number of infested flower}}{\text{Total number of flower}} \times 100$$

**Percent pod infestation by count:** Infested pods were counted from total harvest and yield loss was calculated over control plot.

$$\text{Infestation (\%)} = \frac{\text{Number of infested pod}}{\text{Total number of pod}} \times 100$$

**Percent pod infestation by Weight:** Infested pods were weighted from total harvest and yield loss was calculated over control plot.

$$\text{Infestation (\%)} = \frac{\text{Quantity of infested pod}}{\text{Total quantity of pod}} \times 100$$

**Percent reduction of infestation over control**

$$= \frac{\text{Mean value of the control - Mean value of the treatment}}{\text{Mean value of the control}} \times 100$$

## Apparatus and Instruments Used

Samples were collected from field in Petridishes using fine camel hair brush, sweep net, aspirator.. Hand magnifying glass, insect collection box and bottles with ethanol were used for identification, collection and preservation of insect pests. Stereoscopic microscope fitted with camera was used for taking exclusive photograph. Weighing balance was used for taking weight of healthy and infested pods. Polythene bag, mosquito net and iron cases were used for adult moth identification.

# Chapter IV

# RESULTS AND DISCUSSION

The experiment was conducted to evaluate the effectiveness of chemical and non-chemical control methods for the control of bean pod borer. The analysis of variance (ANOVA) of the data on different components related to yield of bean is given in Appendix III-XI. The results have been presented and discussed, and possible explanations have been given under the following headings:



### 4.1 Number of flower bud/inflorescence

Statistically significant variation was found in number of flower bud per inflorescence in different control methods in controlling bean pod borer (Appendix XI). Highest number of flower bud/inflorescence (18.33) was recorded in $T_5$ treatment (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water), which was closely followed (17.33) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 1). On the other hand the lowest number of flower bud/inflorescence (13.67) was recorded in $T_7$ (Untreated control) treatment which was closely followed (15.00) by was recorded in $T_1$ (Mechanical control of infested flowers and fruits) and $T_2$ (Neem oil @ 30 ml/liter of water), respectively. The infested flower buds, flowers and pods were found webbed together (Karim, 1993). They also burrowed into flower buds and hollowed them out. Some times leaves were spun together and caterpillars fed within the web (Das and Islam, 1985; Singh, 1983). Normally when we apply different control measures in controlling bean pod borer maximum vegetative growth may be attained with less or no damaging of shoot and the ultimate results in the maximum number of flower bud.

### 4.2 Length of flower inflorescence

Length of flower inflorescence showed a statistically significant variation in different control methods in controlling bean pod borer under the present trail (Appendix XI). Maximum length of flower inflorescence (51.67 cm) was recorded in $T_5$ treatment (Mechanical control comprising removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water), which was closely followed (49.00 cm) by $T_6$ (Mechanical control comprising removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment

(Table 1). On the other hand the minimum length of flower inflorescence (38.67 cm) was recorded in $T_7$ (Untreated control) treatment, which was closely followed (42.18 cm) by $T_1$ (Mechanical control removal of infested flowers and fruits).

### 4.3 Width of flower inflorescence

Statistically significant variation was recorded in different control methods in controlling bean pod borer in terms of width of flower inflorescence (Appendix XI). Maximum width of flower inflorescence (6.33 cm) was recorded in $T_5$ treatment (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) which was statistically identical (6.13 cm) by $T_6$ (Mechanical control removal of infested flowers and fruits (Table 1). On the other hand the minimum width of flower inflorescence (5.30 cm) was recorded in $T_7$ (Untreated control) treatment.

**Table 1. Effect of different control methods used against bean pod borer on different characters of flower.**

| Treatment | No. of the flower bud/inflorescence | Length of the flower inflorescence(cm) | Width of the flower inflorescence (cm) |
|---|---|---|---|
| $T_1$ | 15.00 d | 42.18 f | 5.67 b |
| $T_2$ | 15.67d | 45.70 e | 5.90 b |
| $T_3$ | 16.33 c | 47.00 d | 5.93 b |
| $T_4$ | 16.67 c | 48.00 c | 6.10 a |
| $T_5$ | 18.33 a | 51.67 a | 6.33 a |
| $T_6$ | 17.33 b | 49.00 b | 6.13 a |
| $T_7$ | 13.67 e | 38.67 g | 5.30 c |
| $LSD_{0.05}$ | 0.852 | 0.825 | 0.215 |
| Level of significance | ** | ** | ** |
| CV (%) | 5.78 | 4.88 | 4.35 |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , means followed by different letters are significantly different.

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

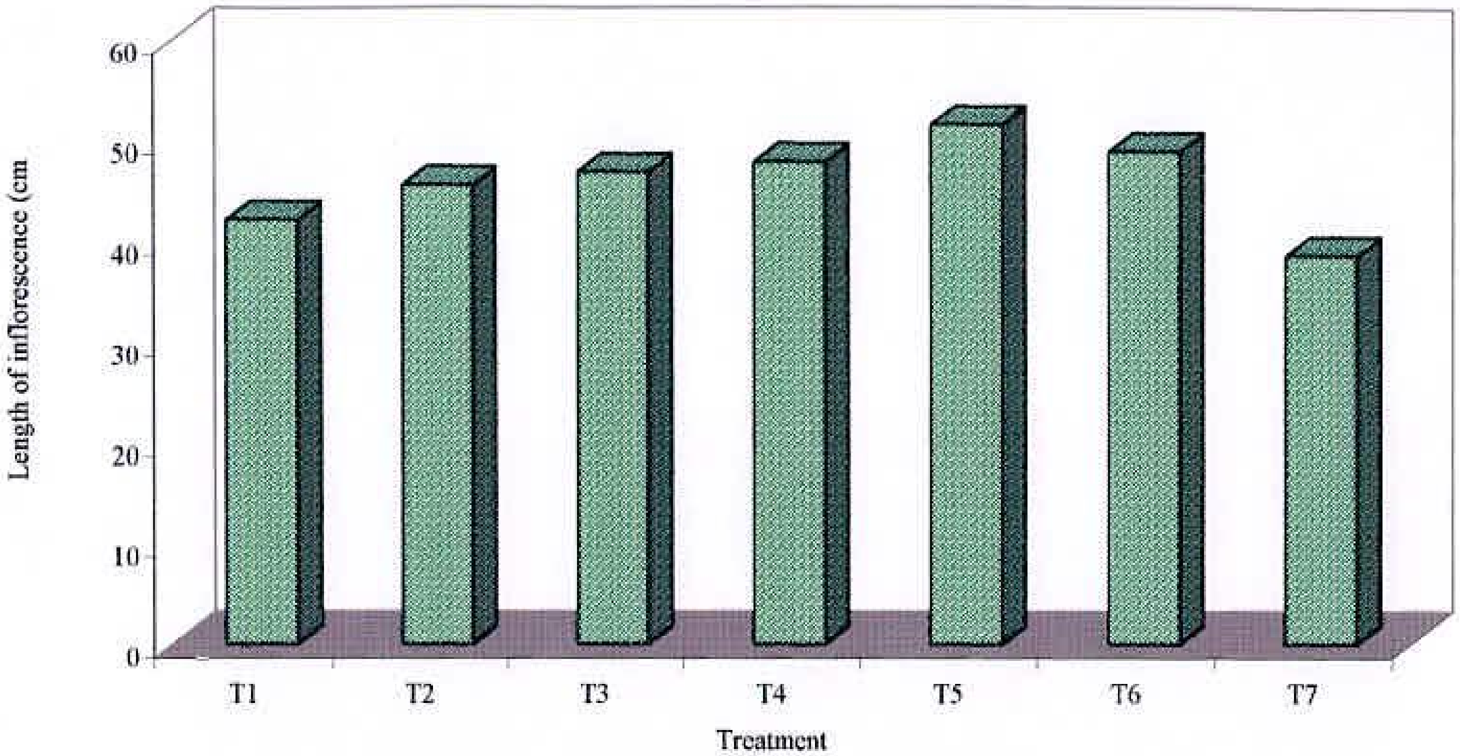


Figure 1. Effect of different control methods on length of inflorescence

$T_1$: Mechanical control removal of infested flowers and fruits

$T_2$: Neem oil @ 30 ml/liter of water at 7 days intervals

$T_3$: Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_4$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals

$T_5$: Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_6$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 10 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_7$ : Untreated control removal

**Plate 5: Healthy Inflorescence**

**Plate 6: Infested Inflorescence**

### 4.4 Fruit bearing status in number at early fruiting stage

### 4.4.1 Number of fruit at 1$^{st}$ harvest

Statistically significant variation was found in number of healthy fruit per plot at 1$^{st}$ harvest in different control methods in controlling bean pod borer under the present trail (Appendix III). Highest number of healthy fruit per plot (13.00) was recorded in $T_5$ (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment, which was closely followed (11.67) by $T_6$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 2). On the other hand the lowest number of healthy fruit (6.33) was recorded in $T_7$ (Untreated control) treatment, which was closely followed (8.00) by $T_1$ (Mechanical control removal of infested flowers and fruits) and $T_4$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water), respectively.

Significant differences was also recorded in terms of number of infested fruit per plot at 1$^{st}$ harvest in different control methods in controlling bean pod borer (Appendix III). Highest number of infested fruit (8.33) was recorded in $T_7$ treatment, which was closely followed by $T_1$ treatment (6.33). On the other hand the lowest number of infested fruit (3.00) was recorded in $T_5$ treatment (Table 2).

Different control methods in controlling bean pod borer in the present study showed a statistically significant difference in terms of % infestation of fruit in number per plot (Appendix III). Highest % of infested fruit in number (56.85%) was recorded in $T_7$ treatment which was closely followed by $T_1$ treatment (44.13%). On the other hand the lowest % of infested fruit in number (18.80%) was recorded in $T_5$ treatment (Table 2) which was closely followed by $T_6$ treatment. In $T_5$ treatment fruit infestation percentage over control in number was estimated the highest value (66.90%) and the lowest value (22.37%) from $T_1$ treatment (Table 2). From the findings it is revealed that treatment $T_5$ performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in number whereas in control treatment the situation is reverse. Dandale *et al*. (1984) found similar results earlier with using different chemicals in their experiments.

### 4.4. Number of fruit at 2$^{nd}$ harvest

In terms of number of healthy fruit per plot at 2$^{nd}$ harvest showed statistically

**Table 2. Effect of different control methods applied against bean pod borer on number of pod at early fruiting stage**

| Treatment | Number of fruit/plot at | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st harvest (10.12.2006) | | | | 2nd harvest (24.12.2006) | | | |
| | Healthy fruit | Infested fruit | % infestation | % infestation over control | Healthy fruit | Infested fruit | % infestation | % infestation over control |
| $T_1$ | 8.00 c | 6.33 b | 44.13 b | 22.37 | 16.33 e | 9.67 b | 37.10 b | 14.97 |
| $T_2$ | 8.67 c | 4.67 c | 34.98 cd | 38.47 | 24.00 d | 8.00 c | 25.00 c | 42.70 |
| $T_3$ | 8.67 c | 4.00 c | 31.62 d | 44.38 | 28.00 c | 6.33 de | 18.32 d | 58.01 |
| $T_4$ | 8.00 c | 4.67 c | 36.85 c | 35.18 | 24.00 d | 7.00 d | 22.60 c | 48.20 |
| $T_5$ | 13.00 a | 3.00 d | 18.80 f | 66.93 | 41.33 a | 5.00 f | 10.82 f | 75.20 |
| $T_6$ | 11.67 b | 4.00 c | 25.56 e | 55.04 | 36.00 b | 6.00 e | 14.29 e | 67.25 |
| $T_7$ | 6.33 d | 8.33 a | 56.85 a | -- | 14.67 e | 11.33 a | 43.63 a | -- |
| $LSD_{0.05}$ | 1.317 | 0.792 | 3.580 | -- | 3.472 | 0.938 | 2.614 | -- |
| Level of significance | ** | ** | ** | -- | ** | ** | ** | -- |
| CV (%) | 8.05 | 8.91 | 5.66 | -- | 7.40 | 6.92 | 5.99 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , , means followed by different letters are significantly different.

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

**Table 3. Effect of different control methods applied against bean pod borer on number of pod at mid fruiting stage**

| Treatment | Number of fruit/plot at | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3rd harvest (07.01.2007) | | | | 4th harvest (21.01.2007) | | | |
| | Healthy fruit | Infested fruit | % infestation | % infestation over control | Healthy fruit | Infested fruit | % infestation | % infestation over control |
| $T_1$ | 29.33 f | 12.67 b | 28.60 a | 3.31 | 38.67 e | 13.00 b | 25.18 b | 13.11 |
| $T_2$ | 67.67 e | 11.33 c | 24.50 b | 17.17 | 48.33 d | 11.33 c | 18.99 c | 34.47 |
| $T_3$ | 53.67 c | 9.00 e | 19.23 cd | 34.99 | 61.00 c | 10.00 d | 14.12 d | 51.28 |
| $T_4$ | 47.67 d | 10.33 d | 20.72 c | 29.95 | 64.67 bc | 11.00 c | 14.54 d | 49.83 |
| $T_5$ | 68.67 a | 6.67 f | 15.93 e | 46.15 | 78.00 a | 8.00 e | 9.30 f | 67.91 |
| $T_6$ | 58.67 b | 8.67 e | 17.83 d | 39.72 | 67.33 b | 9.67 d | 12.56 e | 56.66 |
| $T_7$ | 27.67 f | 14.33 a | 29.58 a | -- | 36.00 e | 14.67 a | 28.98 a | -- |
| $LSD_{0.05}$ | 4.426 | 0.991 | 1.685 | -- | 4.139 | 0.654 | 1.311 | -- |
| Level of significance | ** | ** | ** | -- | ** | ** | ** | -- |
| CV (%) | 5.39 | 5.33 | 4.27 | -- | 4.13 | 3.31 | 4.17 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , , means followed by different letters are significantly different.

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

significant variation among different control methods in controlling bean pod borer (Appendix III). Highest number of healthy fruit (41.33) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (36.00) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 2). On the other hand the lowest number of healthy fruit (14.67) was recorded in $T_7$ (Untreated control) treatment, which was statistically identical (16.33) with treatment $T_1$ (Mechanical control of infested flowers and fruits).

A significant difference was found in terms of number of infested fruit per plot at 2$^{nd}$ harvest among different control methods in controlling bean pod borer under the present trail (Appendix III). Highest number of infested fruit (11.33) was recorded in $T_7$ treatment, which was closely followed by $T_1$ treatment (9.67). On the other hand the lowest number of infested fruit (5.00) was recorded in $T_5$ treatment, which was closely followed (6.00) by $T_6$ treatment (Table 2).

Similar trend of results also found for mid and late flowering stage at 3$^{rd}$, 4$^{th}$, 5$^{th}$, 6$^{th}$ and 7$^{th}$ harvest (Table 3 and Table 4). Percentage of fruit infestation was presented in Figure 2. Percent fruit infestation in number decreases with increasing harvesting time but maximum healthy fruit was found in mid flowering stage.

**4.4.3 Total number of healthy fruit**

Total number of healthy fruit per plot showed a statistically significant difference among different control methods in controlling bean pod borer under the present experiment (Appendix VI). Highest total number of healthy fruit (598.33) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment, which was closely followed (488.67) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 5). On the other the lowest total number of healthy fruit (277.33) was recorded in $T_7$ (Untreated control) treatment which was closely followed (306.67) by the treatment $T_1$ (Mechanical control of infested flowersand fruits). From the results it was found that treatment $T_5$ was most effective in controlling bean pod borer which ensure maximum number of fruit.

**Table 4. Effect of different control methods applied against bean pod borer on number of pod at late fruiting stage**

| Treatment | Number of fruit/plot at | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5th harvest (04.02.2007) | | | | 6th harvest (18.02.2007) | | | | 7th harvest (04.03.2007) | | | |
| | Healthy fruit | Infested fruit | % infestation | % infestation over control | Healthy fruit | Infested fruit | % infestation | % infestat-ion over control | Healthy fruit | Infested fruit | % infestati on | % infestatio n over control |
| $T_1$ | 54.67 e | 14.00 b | 20.38 b | 18.09 | 64.67 e | 15.67 b | 19.54 b | 22.89 | 95.00 e | 19.00 b | 16.68 b | 18.75 |
| $T_2$ | 61.00 d | 12.00 c | 16.44 c | 33.92 | 73.33 d | 14.33 c | 16.36 c | 35.44 | 108.00 d | 16.67 c | 13.37 c | 34.88 |
| $T_3$ | 79.67 bc | 11.00 cd | 12.13 e | 51.25 | 91.67 bc | 13.00 c | 12.42 e | 50.99 | 128.7 bc | 16.33 c | 11.26 d | 45.15 |
| $T_4$ | 74.33 c | 12.00 c | 13.91 d | 44.09 | 86.33 c | 14.33 c | 14.24 d | 43.80 | 124.00 c | 16.33 c | 11.64 d | 43.30 |
| $T_5$ | 118.33 a | 8.33 e | 6.59 g | 73.51 | 122.67 a | 9.67 e | 7.32 g | 71.11 | 156.33 a | 12.67 d | 7.50 e | 63.47 |
| $T_6$ | 85.00 b | 10.33 d | 10.84 f | 56.43 | 96.00 b | 11.00 d | 10.34 f | 59.19 | 134.00 b | 13.00 d | 8.85 e | 56.89 |
| $T_7$ | 50.33 e | 16.67 a | 24.88 a | -- | 56.00 f | 19.00 a | 25.34 a | -- | 86.33 f | 22.33 a | 20.53 a | -- |
| $LSD_{0.05}$ | 5.825 | 0.978 | 1.195 | -- | 5.721 | 1298 | 1.404 | -- | 6.288 | 1.848 | 1.496 | -- |
| Level of significance | ** | ** | ** | -- | ** | ** | ** | -- | ** | ** | ** | -- |
| CV (%) | 4.38 | 4.56 | 4.47 | -- | 3.81 | 5.26 | 5.23 | -- | 2.97 | 6.25 | 6.55 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot, , means followed by different letters are significantly different

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

### 4.4.4 Total number of infested fruit

Total number of infested fruit per plot showed a statistically significant difference among different control methods in controlling bean pod borer (Appendix VI). Highest total number of infested fruit (106.67) was recorded in $T_7$ (Untreated control) treatment which was closely followed (90.33) by $T_1$ (Mechanical control of infested flowers and fruits) treatment (Table 5). On the other the lowest total number of infested fruit (53.33) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (62.67) by the treatment $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water). From the results it was found that treatment $T_5$ was most effective in controlling bean pod borer which ensured minimum infested shoot as well as minimum number of infested fruit whereas control treatment maximum infested fruit.

### 4.4.5 Average number of healthy fruit

A statistically significant difference among different control methods in controlling bean pod borer in terms of average number of healthy fruit per plot was recorded (Appendix VI). Highest average number of healthy fruit per harvest per plot (85.48) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (69.81) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 5). On the other hand the lowest total number of healthy fruit (38.62) was recorded in $T_7$ (Untreated control) treatment which was closely followed (43.81) by the treatment $T_1$ (Mechanical control of infested flowers and fruits). From the results it was found that treatment $T_5$ was the most effective in controlling bean pod borer which ensured maximum healthy shoot as well as highest average fruit per harvest in every experimental plot.

### 4.4.6 Average number of infested fruit

Average number of infested fruit per plot per harvest showed a statistically significant difference among different control methods in controlling bean pod borer under the present study (Appendix VI). Highest average number of infested fruit (15.24) was recorded in $T_7$ (Untreated control) treatment which was closely followed (12.91) by $T_1$ (Mechanical control of infested flowers and fruits) treatment (Table 5). On the other hand the lowest average number of infested fruit (7.62) was recorded in $T_5$ (Mechanical control of

**Table 5. Effect of different control methods applied against bean pod borer on number of pod at early, mid, late fruiting stage**

| Treatment | Total number of healthy fruit | Total number of infested fruit | Average number of healthy fruit | Average number of infested fruit | % Average Infestation | % infestation over control |
|---|---|---|---|---|---|---|
| $T_1$ | 306.67 f | 90.33 b | 43.81 f | 12.91 b | 22.75 b | 18.11 |
| $T_2$ | 361.00 e | 78.33 c | 51.57 e | 11.19 c | 17.83 c | 35.82 |
| $T_3$ | 451.67 c | 69.67 d | 64.52 c | 9.95 d | 13.37 e | 51.87 |
| $T_4$ | 429.00 d | 75.67 c | 61.29 d | 10.81 c | 14.99 d | 46.04 |
| $T_5$ | 598.33 a | 53.33 f | 85.48 a | 7.62 f | 8.19 g | 70.52 |
| $T_6$ | 488.67 b | 62.67 e | 69.81 b | 8.95 e | 11.37 f | 59.07 |
| $T_7$ | 277.33 g | 106.67 a | 38.62 g | 15.24 a | 27.78 a | -- |
| $LSD_{0.05}$ | 11.81 | 2.994 | 1.688 | 0.428 | 0.705 | -- |
| Level of significance | ** | ** | ** | ** | ** | -- |
| CV (%) | 1.60 | 2.20 | 1.60 | 2.20 | 2.39 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , means followed by different letters are significantly different

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

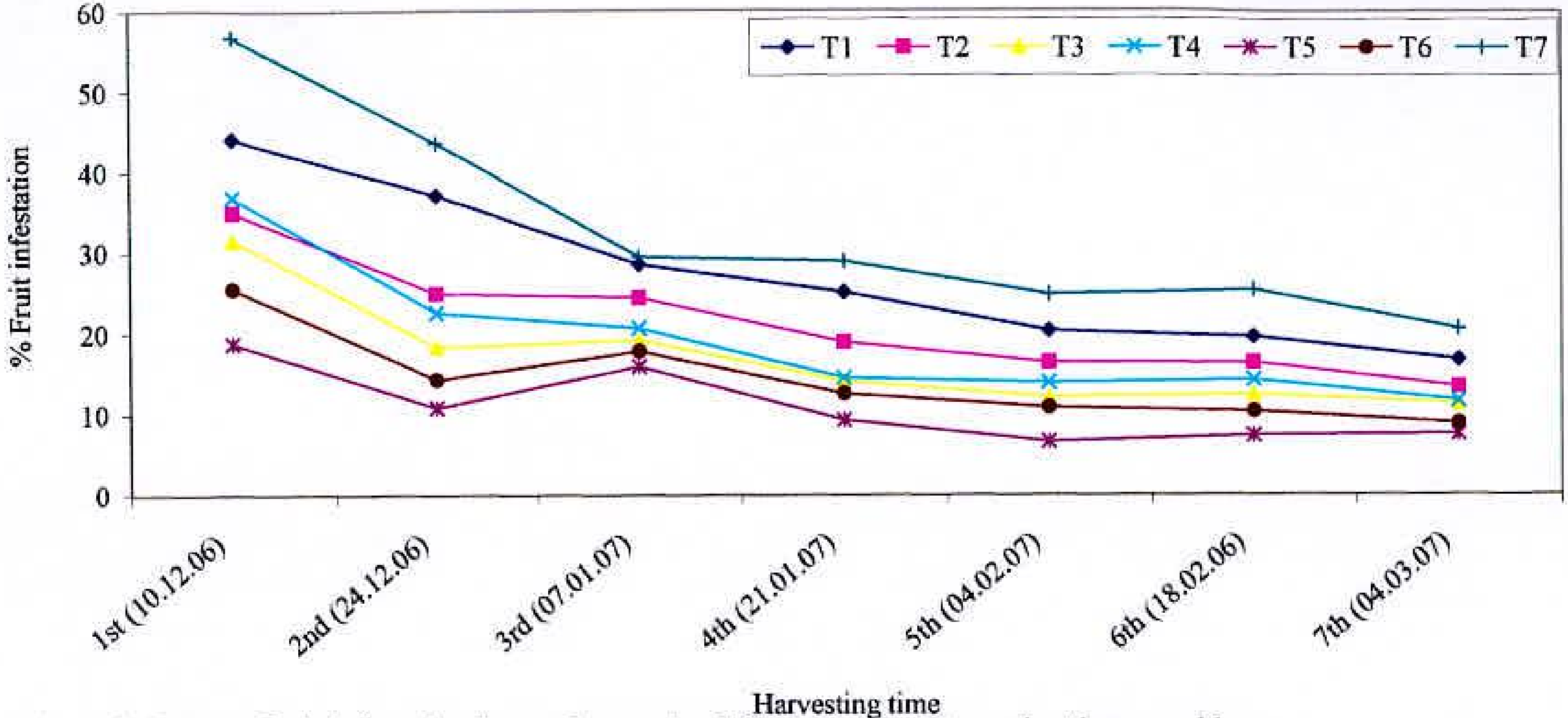


**Figure 2. Percent fruit infestation in number under differnt treatments against bean pod borer**

$T_1$: Mechanical control removal of infested flowers and fruits
$T_2$: Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$: Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$: Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 10 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control removal

infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (8.95) by the treatment $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water).

### 4.4.7 Average % infested fruit in number

Average % infested fruit in number per plot per harvest showed a statistically significant difference among different control methods in controlling bean pod borer (Appendix VI). Highest % of average infested fruit in number (27.78%) was recorded in $T_7$ (Untreated control) treatment which was closely followed (22.75%) by $T_1$ (Mechanical control of infested flowers and fruits) treatment (Table 5). On the other hand the lowest % of average infested fruit in number (8.19%) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (11.37%) by the treatment $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water).

### 4.4.8 Average % infested fruit over control in number

Average % infested fruit over control in number per plot per harvest showed a statistically significant difference among different control methods in controlling bean pod borer (Appendix VI). Highest % of average infested fruit over control in number (70.52%) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (59.07%) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 5). On the other the lowest % of average infested fruit over control in number (18.11%) was recorded in $T_1$ (Mechanical control of infested flowers and fruits) treatment which was closely followed (35.82%) by the treatment $T_2$ (Neem oil @ 30 ml/liter of water).

## 4.5 Fruit bearing status in weight at early fruiting stage

### 4.5.1 Weight of fruit at 1$^{st}$ harvest

Statistically significant difference was recorded in weight of healthy fruit per plot at 1$^{st}$ harvest in different control methods in controlling bean pod borer under the present trail (Appendix VII). Highest weight of healthy fruit (151.67 g) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (128.33 g) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 6).

**Table 6. Effect of different control methods applied against bean pod borer on weight of pod at early fruiting stage**

| Treatment | Weight of fruit/plot (g)at | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st harvest (10.12.2006) | | | | 2nd harvest (24.12.2006) | | | |
| | Healthy fruit | Infested fruit | % infestation | % infestation over control | Healthy fruit | Infested fruit | % infestation | % infestation over control |
| $T_1$ | 88.33 d | 45.17 b | 33.79 b | 20.48 | 203.33 e | 80.17 a | 28.21 b | 10.02 |
| $T_2$ | 98.00 d | 30.00 c | 23.41 c | 44.90 | 295.67 d | 61.33 b | 17.18 c | 45.20 |
| $T_3$ | 104.33 c | 21.67 e | 17.23 d | 59.45 | 346.00 c | 49.00 c | 12.50 e | 60.13 |
| $T_4$ | 91.67 cd | 26.33 d | 22.41 c | 47.26 | 296.67 d | 57.33 b | 16.22 d | 48.26 |
| $T_5$ | 151.67 a | 11.67 g | 7.15 f | 83.17 | 500.00 a | 30.50 d | 5.79 g | 81.53 |
| $T_6$ | 128.33 b | 15.67 f | 10.97 e | 74.18 | 436.67 b | 44.00 c | 9.15 f | 70.81 |
| $T_7$ | 78.00 e | 57.67 a | 42.49 a | -- | 183.67 f | 83.67 a | 31.35 a | -- |
| $LSD_{0.05}$ | 10.25 | 2.526 | 3.158 | -- | 14.251 | 5.458 | 3.125 | -- |
| Level of significance | ** | ** | ** | -- | ** | ** | ** | -- |
| CV (%) | 8.28 | 10.22 | 10.10 | -- | 7.84 | 6.07 | 7.62 | -- |

In a column, numeric data represents the mean value of 3 replicatiopns; each replication is derived from 4 plants in a plot , means followed by different letters are significantly different

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

**Table 7. Effect of different control methods applied against bean pod borer on the weight of pod at mid fruiting stage**

| Treatment | Weight of fruit/plot (g)at | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3rd harvest (07.01.2007) | | | | 4th harvest (21.01.2007) | | | |
| | Healthy fruit | Infested fruit | % infestation | % infestation over control | Healthy fruit | Infested fruit | % infestation | % infestation over control |
| $T_1$ | 327.00 e | 90.17 b | 21.70 b | 13.68 | 472.00 d | 96.83 b | 17.04 b | 12.53 |
| $T_2$ | 420.00 d | 77.67 c | 15.59 c | 37.99 | 586.00 c | 80.00 c | 12.01 c | 38.35 |
| $T_3$ | 593.00 c | 61.00 d | 9.38 e | 62.69 | 737.00 b | 64.33 f | 8.05 d | 58.68 |
| $T_4$ | 530.33 c | 70.67 c | 11.76 d | 53.22 | 782.67 b | 77.33 d | 8.99 d | 53.85 |
| $T_5$ | 761.00 a | 39.33 f | 4.91 f | 80.47 | 939.67 a | 46.33 g | 4.70 f | 75.87 |
| $T_6$ | 650.33 b | 55.00 e | 7.80 e | 68.97 | 816.33 ab | 59.67 f | 6.81 e | 65.04 |
| $T_7$ | 309.67 e | 104.00 a | 25.14 a | -- | 439.00 d | 106.17 a | 19.48 a | -- |
| $LSD_{0.05}$ | 64.57 | 14.52 | 3.54 | -- | 43.58 | 8.54 | 1.458 | -- |
| Level of significance | ** | ** | ** | -- | ** | ** | ** | -- |
| CV (%) | 5.39 | 6.20 | 8.43 | -- | 3.80 | 3.55 | 4.11 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , means followed by different letters are significantly different

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

On the other hand the lowest weight of healthy fruit (78.00 g) was recorded in $T_7$ (Untreated control) treatment which was closely followed (88.33 g) by was recorded in $T_1$ (Mechanical control of infested flowers and fruits) and $T_2$ (Neem oil @ 30 ml/liter of water), respectively.

Significant variation was recorded in terms of weight of infested fruit per plot at 1st harvest in different control methods in controlling bean pod borer (Appendix VII). Highest weight of infested fruit (57.67 g) was recorded in $T_7$ treatment which was closely followed by $T_1$ treatment (45.17 g). On the other hand the lowest weight of infested fruit (11.67 g) was recorded in $T_5$ treatment (Table 5).

Different control methods in controlling bean pod borer showed a statistically significant difference in terms of % infestation of fruit in weight per plot (Appendix VII). Highest % of infested fruit in weight (42.49%) was recorded in $T_7$ treatment which was closely followed by $T_1$ treatment (33.79%). On the other hand the lowest % of infested fruit in weight (7.15%) was recorded in $T_5$ treatment (Table 5) which was closely followed by $T_6$ treatment (10.97%). In $T_5$ treatment fruit infestation in percentage over control in weight was estimated the highest value (83.17%) and the lowest value (20.48%) from $T_1$ treatment (Table 5). From the findings it revealed that treatment $T_5$ performed maximum healthy fruit and minimum infested fruit as well as lowest % of fruit infestation in weight where as control condition performed the reverse situation.

### 4.5.2 Weight of fruit at 2nd harvest (early fruiting stage)

In terms weight of healthy fruit per plot at 2nd harvest statistically significant variation was recorded among different control methods in controlling bean pod borer (Appendix VII). Highest weight of healthy fruit (500.00 g) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (436.67 g) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 5). On the other the lowest weight of healthy fruit (183.67 g) was recorded in $T_7$ (Untreated control) treatment which was closely followed (203.33) by the treatment $T_1$ (Mechanical control of infested flowers and fruits).

A significant difference was recorded in terms of weight of infested fruit per plot at 2nd harvest in different control methods in controlling bean pod borer under the present trail (Appendix VII). Highest weight of infested fruit (83.67 g) was recorded in $T_7$ treatment which was statistically similar with $T_1$ treatment (80.17 g). On the other the lowest weight of

**Table 8. Effect of different control methods applied against bean pod borer on the weight of pod at late fruiting stage**

| Treatment | Weight of fruit/plot (g) at | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5th harvest (04.02.2007) | | | | 6th harvest (18.02.2007) | | | | 7th harvest (04.03.2007) | | | |
| | Healthy fruit | Infested fruit | % infestation | % infestation over control | Healthy fruit | Infested fruit | % infestation | % infestation over control | Healthy fruit | Infested fruit | % infestation | % infestation over control |
| $T_1$ | 603.00 f | 116.83 b | 16.22 b | 11.17 | 780.00 f | 132.83 b | 14.59 b | 29.14 | 954.83 e | 152.83 b | 13.81 b | 27.47 |
| $T_2$ | 676.00 e | 98.00 c | 12.66 c | 30.67 | 881.33 e | 117.67 c | 11.78 c | 42.79 | 1083.00 d | 131.00 c | 10.79 c | 43.33 |
| $T_3$ | 882.33 c | 83.67 d | 8.66 e | 52.57 | 1105.00 c | 101.17 d | 8.39 d | 59.25 | 1289.33 c | 126.00 d | 8.90 e | 53.26 |
| $T_4$ | 821.00 d | 96.00 c | 10.47 d | 42.66 | 1041.00 d | 118.67 c | 10.23 cd | 50.32 | 1243.33 c | 128.67 d | 9.38 d | 50.74 |
| $T_5$ | 1306.83 a | 56.67 f | 4.17 g | 77.16 | 1489.33 a | 69.33 f | 4.46 e | 78.34 | 1570.00 a | 89.33 f | 5.39 f | 71.69 |
| $T_6$ | 939.67 b | 75.33 e | 7.42 f | 59.36 | 1142.83 b | 84.67 e | 6.95 de | 66.25 | 1346.67 b | 93.33 e | 6.49 f | 65.91 |
| $T_7$ | 560.67 g | 125.33 a | 18.26 a | -- | 675.67 g | 174.67 a | 20.59 a | -- | 867.67 f | 204.00 a | 19.04 a | -- |
| $LSD_{0.05}$ | 47.59 | 18.45 | 1.251 | -- | 45.85 | 14.251 | 2.782 | -- | 47.89 | 3.258 | 1.224 | -- |
| Level of significance | ** | ** | ** | -- | ** | ** | ** | -- | ** | ** | ** | -- |
| CV (%) | 4.53 | 7.60 | 7.40 | -- | 3.72 | 5.80 | 7.98 | -- | 3.01 | 4.32 | 5.67 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , means followed by different letters are significantly different

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

infested fruit (30.50 g) was recorded in $T_5$ treatment which was closely followed (44.00 g) by $T_6$ treatment (Table 6).

Different control methods in controlling bean pod borer under the present trail showed a statistically significant difference in terms of % infestation of fruit per plot in weight (Appendix VII). Highest % of infested fruit in weight (31.35%) was recorded in $T_7$ treatment which was closely followed by $T_1$ treatment (28.21%). On the other hand the lowest % of infested fruit in weight (5.79%) was recorded in $T_5$ treatment (Table 5) which was closely followed by $T_6$ treatment (9.15%). In $T_5$ treatment fruit infestation in percentage over control in weight was estimated the highest value (81.53%) and the lowest value (10.02%) from $T_1$ treatment (Table 6).

Similar trend of result in weight of infested fruit also found for mid and late flowering stage at 3$^{rd}$, 4$^{th}$, 5$^{th}$, 6$^{th}$ and 7$^{th}$ harvest (Table 7 and 8). Percentage of fruit infestation in weight per plot was presented in Figure 1. Percent fruit infestation in number decreases with increasing harvesting time but maximum healthy fruit in weight per plot was found in mid flowering stage.

**4.5.3 Total weight of healthy fruit**

Total weight of healthy fruit per plot showed a statistically significant difference among different control methods in controlling bean pod borer (Appendix X). Highest total weight of healthy fruit (6718.50 g) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (5460.83 g) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 9). On the other hand the lowest total weight of healthy fruit (3114.35 g) was recorded in $T_7$ (Untreated control) treatment which was closely followed (3428.49 g) by the treatment $T_1$ (Mechanical control of infested flowers and fruits). From the results it was found that treatment $T_5$ was the most effective in controlling bean pod borer which ensure the maximum number of healthy fruit as well as maximum weight of fruit.

**Table 9. Effect of different control methods applied against bean pod borer on the weight of pod at early, Mid, late fruiting stage**

| Treatment | Total weight of healthy fruit (g) | Total weight of infested fruit | Average weight of healthy fruit | Average weight of infested fruit | % Average Infestation | % infestation over control |
|---|---|---|---|---|---|---|
| $T_1$ | 3428.49 f | 714.83 b | 489.78 f | 102.12 b | 20.77 b | 17.57 |
| $T_2$ | 4040.00 e | 595.67 c | 577.14 e | 85.10 c | 14.77 c | 41.36 |
| $T_3$ | 5056.99 c | 506.84 d | 722.43 c | 72.41 d | 10.44 e | 58.54 |
| $T_4$ | 4806.67 d | 575.00 d | 686.67 d | 82.14 c | 12.78 d | 49.27 |
| $T_5$ | 6718.50 a | 343.16 e | 959.79 a | 49.02 e | 5.22 g | 79.26 |
| $T_6$ | 5460.83 b | 427.67 d | 780.12 b | 61.10 d | 7.94 f | 68.48 |
| $T_7$ | 3114.35 g | 855.51 a | 444.91 g | 122.22 a | 25.19 a | -- |
| $LSD_{0.05}$ | 285.45 | 98.58 | 28.55 | 9.58 | 2.152 | -- |
| Level of significance | ** | ** | ** | ** | ** | -- |
| CV (%) | 4.27 | 2.73 | 1.69 | 3.18 | 2.20 | -- |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , means followed by different letters are significantly different

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

### 4.5.4 Total weight of infested fruit

Total weight of infested fruit per plot showed a statistically significant difference among different control methods in controlling bean pod borer (Appendix X). Highest total weight of infested fruit (855.51 g) was recorded in $T_7$ (Untreated control) treatment which was closely followed (714.83 g) by $T_1$ (Mechanical control of infested flowers and fruits) treatment (Table 8). On the other hand the lowest total weight of infested fruit (343.16 g) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (427.67 g) by the treatment $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water). From the results it was found that treatment $T_5$ was the most effective in controlling bean pod borer which ensured minimum infested shoot as well as minimum weight of infested fruit whereas control treatment had maximum infested fruit.

### 4.5.5 Average weight of healthy fruit

A statistically significant difference among different control methods in controlling bean pod borer in terms of average weight of healthy fruit per plot was recorded under the present experiment (Appendix X). Highest average weight of healthy fruit per harvest per plot (959.79 g) was recorded in $T_5$ (Mechanical control of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (780.12 g) by $T_6$ (Mechanical control of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 8). On the other the lowest total weight of healthy fruit (444.91 g) was recorded in $T_7$ (Untreated control) treatment which was closely followed (489.78 g) by the treatment $T_1$ (Mechanical control of infested flowers and fruits). From the results it was found that treatment $T_5$ was most effective for controlling bean pod borer which ensure the maximum healthy shoot as well as highest average fruit per harvest in every experimental plot.

### 4.5.6 Average weight of infested fruit

Average weight of infested fruit per plot per harvest showed a statistically significant difference among different control methods in controlling bean pod borer under the present trail (Appendix X). Highest average weight of infested fruit (122.22 g) was recorded in $T_7$ (Untreated control) treatment which was closely followed (102.12 g) by $T_1$ (Mechanical control of infested flowers and fruits) treatment (Table 8). On the other the

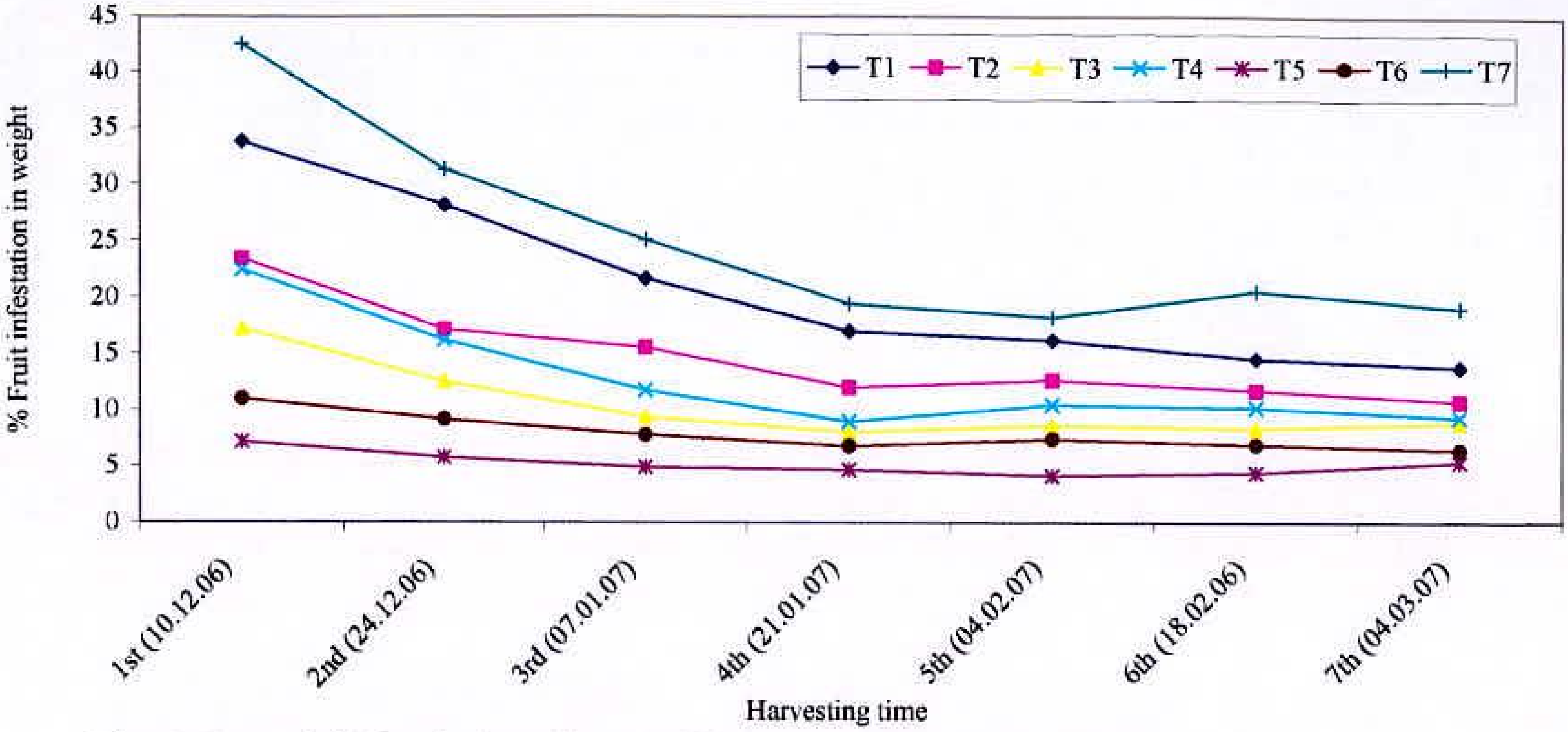


Figure 3. Percent fruit infestation in weight under different treatments against bean pod borer

$T_1$: Mechanical control removal of infested flowers and fruits

$T_2$: Neem oil @ 30 ml/liter of water at 7 days intervals

$T_3$: Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_4$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals

$T_5$: Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_6$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 10 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_7$ : Untreated control removal

the lowest average weight of infested fruit (49.02 g) was recorded in $T_5$ (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (61.10 g) by the treatment $T_6$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water).

### 4.5.7 Average % infested fruit in weight

Average % infested fruit in weight per plot per harvest showed a statistically significant difference among different control methods in controlling bean pod borer (Appendix X). Highest % of average infested fruit in weight (25.19%) was recorded in $T_7$ (Untreated control) treatment which was closely followed (20.77%) by $T_1$ (Mechanical control removal of infested flowers and fruits) treatment (Table 8). On the other the lowest % of average infested fruit in weight (5.22%) was recorded in $T_5$ (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (7.94%) by the treatment $T_6$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water).

### 4.5.8 Average % infested fruit over control in weight

Average % infested fruit over control in weight per plot per harvest showed a statistically significant difference among different control methods in controlling bean pod borer (Appendix X). Highest % of average infested fruit over control in weight (79.26%) was recorded in $T_5$ (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) treatment which was closely followed (68.48%) by $T_6$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 8). On the other the lowest % of average infested fruit over control in weight (17.57%) was recorded in $T_1$ (Mechanical control removal of infested flowers and fruits) treatment which was closely followed (41.36%) by the treatment $T_2$ (Neem oil @ 30 ml/liter of water).

## 4.6 Relationship between temperature, rainfall with % infestation of fruit in number and weight basis

A relationship was established between temperature, rainfall with % infestation of fruit in number and weight basis and found a relationship (Figure 4 and 5). Increasing trend of temperature increased the activity of bean pod borer and reduced the number of bean as well as weight/plant. Rainfall also increased the activity of borer which also reduced the yield.

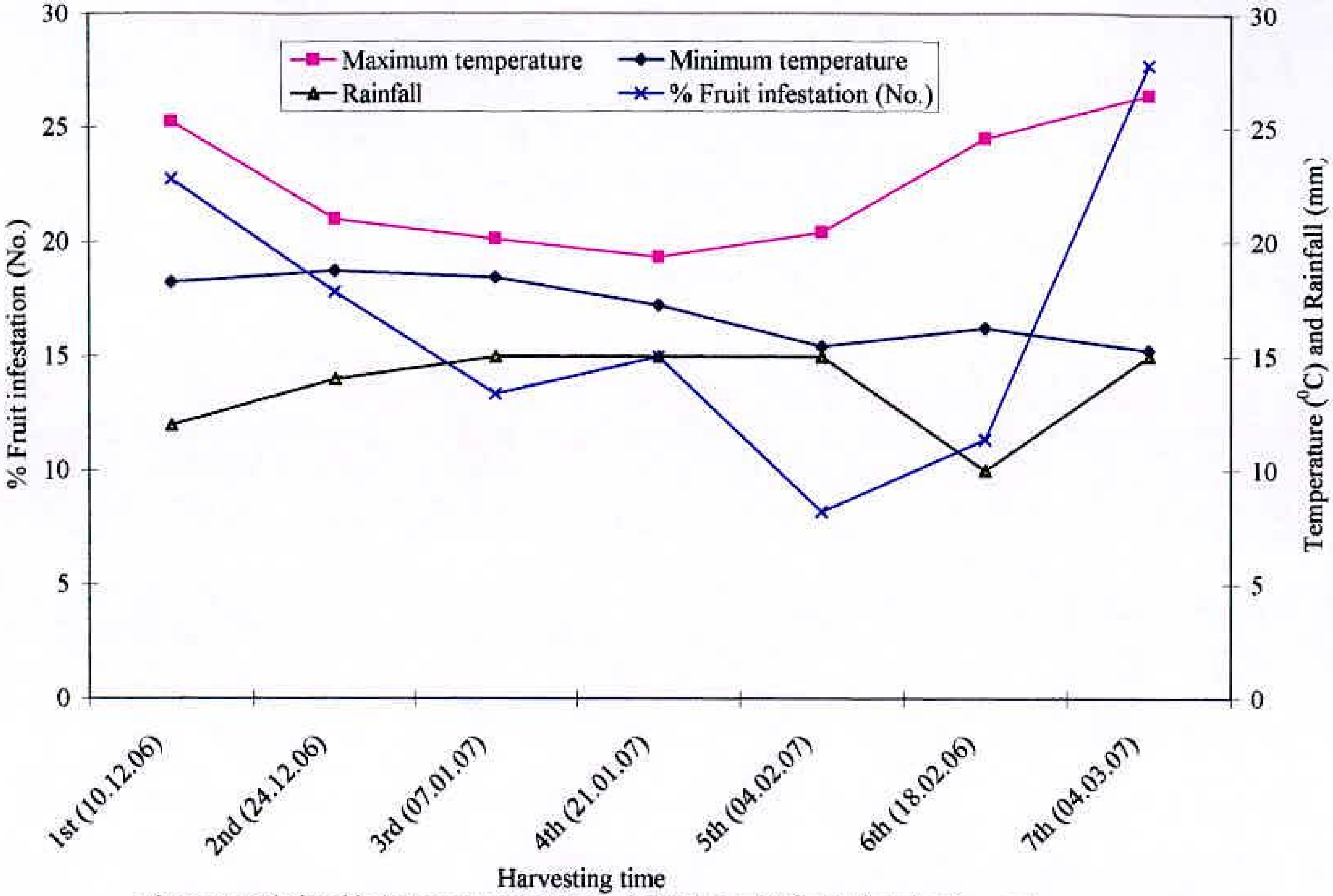


Figure 4. Relationship between Temperature, Rainfall and % fruit infestation in number

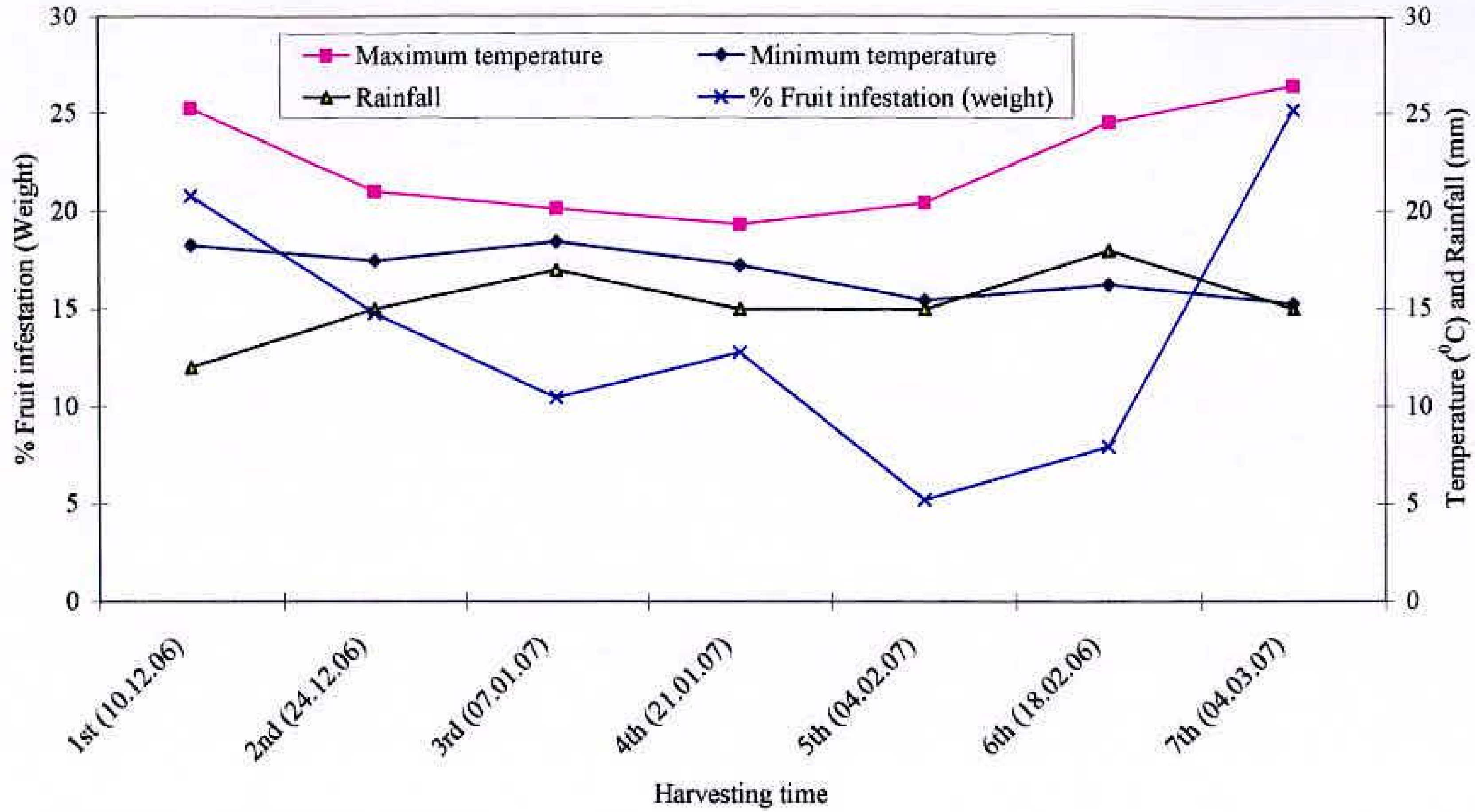


Figure 5. Relationship between % Fruit infestation (weight) with Temperature, Rainfall

### 4.7 Weight of single fruit

Weight of single fruit showed a statistically significant variation in different control methods in controlling bean pod borer (Appendix XI). Highest weight of single fruit (11.80 g) was recorded in $T_5$ treatment (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) which was closely followed (11.33) by $T_6$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 10). On another way the lowest weight of single fruit (8.83 g) was recorded in $T_7$ (Untreated control) treatment which was closely followed (9.73) by was recorded in $T_1$ (Mechanical control removal of infested flowers and fruits) treatment. Different control measures ensure proper vegetative growth by reducing shoot infestation and also produced healthy fruit. So, maximum weight of single fruit would be attained from effective control measures. On the contrary the untreated control treatment produced lowest single fruit weight by hindering vegetative growth resulting deformed shaped bean.

### 4.8 Length of single fruit

Length of single fruit in different control methods in controlling bean pod borer showed a statistically significant difference (Appendix XI). Maximum length of single fruit (11.90 cm) was recorded in $T_5$ treatment (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) which was statistically identical (11.63 cm) by $T_6$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 10). On the other hand the minimum length of single fruit (9.83 cm) was recorded in $T_7$ (Untreated control) treatment which was closely followed (10.30 cm) by was recorded in $T_1$ (Mechanical control removal of infested flowers and fruits) treatment. Probably, control measures ensure optimum photosynthesis as well as maximum accumulation of nutrients which ultimately contributed to increase the length of the fruit.

**Plate 7: Infested pod**

**Plate 8: Infested pod with larva**

**Plate 9: Infested pod with larval excreta**

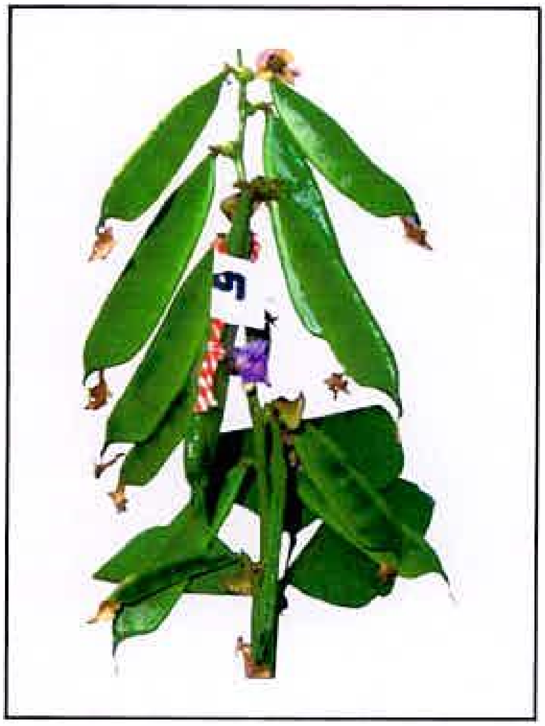

**Plate 10: Healthy pod**

**Table 10. Effect of different control methods applied against on yield and fruit related characters bean pod borer**

| Treatment | Weight of single fruit (g) | Length of single fruit (cm) | Yield (t/ha) |
|---|---|---|---|
| $T_1$ | 9.73 d | 10.30 c | 10.36 f |
| $T_2$ | 10.10 c | 10.58 c | 11.59 e |
| $T_3$ | 10.67 c | 10.83 bc | 13.91 c |
| $T_4$ | 10.90 c | 11.20 b | 13.45 d |
| $T_5$ | 11.80 a | 11.90 a | 17.65 a |
| $T_6$ | 11.33 b | 11.63 a | 14.72 b |
| $T_7$ | 8.83 e | 9.83 d | 9.93 g |
| $LSD_{0.05}$ | 0.428 | 0.524 | 0.313 |
| Level of significance | ** | ** | ** |
| CV (%) | 7.42 | 3.78 | 4.85 |

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 4 plants in a plot , means followed by different letters are significantly different

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removalof infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

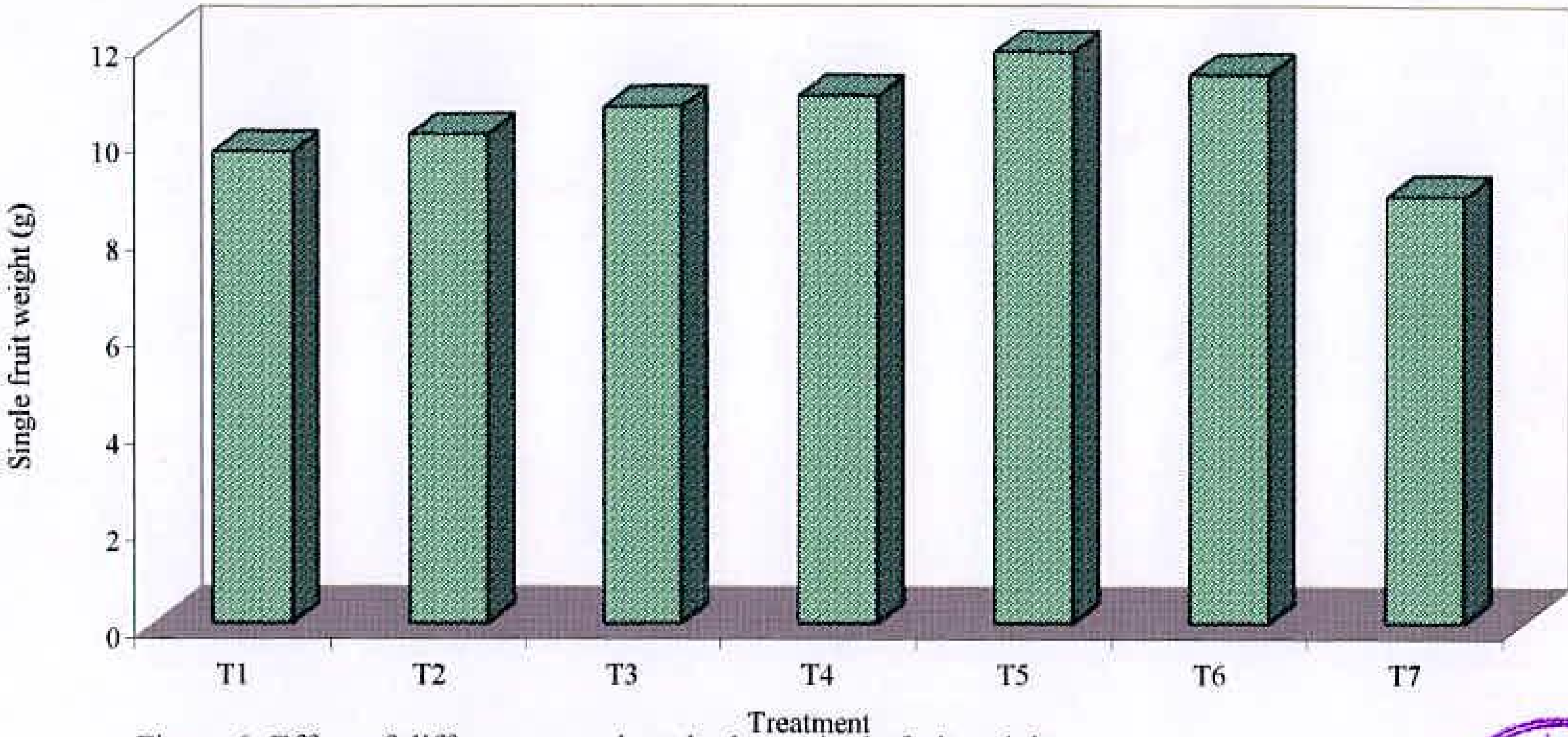


Figure 6. Effect of different control methods on single fruit weight

$T_1$: Mechanical control removal of infested flowers and fruits

$T_2$: Neem oil @ 30 ml/liter of water at 7 days intervals

$T_3$: Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_4$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals

$T_5$: Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_6$: Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 10 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval

$T_7$ : Untreated control removal

#### 4.9 Yield/hectare

Statistically significant variation in yield per hectare among different control methods in controlling bean pod borer under the present trail (Appendix XI). Highest yield per hectare (17.65 t/ha) was recorded in $T_5$ treatment (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water) which was closely followed (14.72 t/ha) by $T_6$ (Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water + Ripcord 10 EC @ 2 ml/Liter of water) treatment (Table 10). On the other hand the lowest yield (9.93 t/ha) was recorded in $T_7$ (Untreated control) treatment which was closely followed (10.36 t/ha) by in $T_1$ (Mechanical control removal of infested flowers and fruits) treatment. Different control measures ensure the optimum vegetative growth and highest and longest inflorescence as well as maximum yield per hectare. Bean pod borer was reported as a major pest of country bean in Bangladesh reported by several workers (Karim, 1993, Das, 1998). This pest has been reported to cause serious damage to legume crops including country bean in many countries (Singh, 1983; Butani and Jotwani, 1994; Singh and Jackai, 1988; Singh and Taylor, 1978).

#### 4.10 Cost analysis

Economic analysis of different non-chemical control measures integrated with or without insecticide for the control of bean pod borer, *Maruca testulalis*, is presented in Table 11.

In this study, the untreated control ($T_7$) did not require any pest management cost. But the costs was involved in mechanical control ($T_1$) for the removal of the infested flowers and fruits as well as for clean cultivation. The cost for the treatment of neem oil @ 30 ml per liter of water 7 days intervals ($T_2$) was incurred for neem oil, trix liquid detergent, preparation and its application. For Ripcord 10 EC @2ml/liter of water applied at 7 days interval ($T_3$) treatments. The cost involved for insecticide and its application. In case of the treatment with mechanical control + neem oil ($T_4$). The cost was incurred for labor, neem oil, detergent preparation and application. The treatment comprising mechanical control + Ripcord 10 EC ($T_5$) required the cost of labor, insecticide and its application cost. The treatment composed of mechnical control + neem oil and Ripcord 10 EC sprayed alternatively at 7 days interval ($T_6$) needed, the cost of labor, insecticide, neem oil, detergent preparation and their application.

Considering the controlling of pod borer highest benefit cost ratio (2.89) was recorded in the treatment $T_5$ (Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter water). In mechanical control negative cost benefit ratio (-0.51) was recorded (Table 11).

**Table 11. Economic analysis of different control measures for controlling bean pod borer**

| Treatments | Cost of pest Management (Tk.) | Yield (t/ha) | Gross return (Tk.) | Net Return (Tk.) | Adjusted net return (Tk.) | Benefit cost ratio |
|---|---|---|---|---|---|---|
| $T_1$ | 13200 | 10.36 | 155400 | 142200 | -6750 | -0.51 |
| $T_2$ | 70400 | 11.59 | 173850 | 103450 | 103450 | 1.47 |
| $T_3$ | 55200 | 13.91 | 208650 | 153450 | 153450 | 2.78 |
| $T_4$ | 83600 | 13.45 | 201750 | 118150 | 118150 | 1.41 |
| $T_5$ | 68400 | 17.72 | 265800 | 197400 | 197400 | 2.89 |
| $T_6$ | 138800 | 14.72 | 220800 | 82000 | 82000 | 0.59 |
| $T_7$ | 0 | 9.93 | 148950 | 148950 | 148950 | 0.00 |

$T_1$ : Mechanical control removal of infested flowers and fruits
$T_2$ : Neem oil @ 30 ml/liter of water at 7 days intervals
$T_3$ : Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_4$ : Mechanical control removalof infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals
$T_5$ : Mechanical control removal of infested flowers and fruits + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_6$ : Mechanical control removal of infested flowers and fruits + Neem oil @ 30 ml/liter of water at 7 days intervals + Ripcord 10 EC @ 2 ml/Liter of water at 7 days interval
$T_7$ : Untreated control

Labor cost : @ Tk. 70/day;
Neem Oil cost : @ Tk. 165 per liter
Ripcord cost @ Tk. 70.00/250 ml bottle
Market price of bean 15 Tk. / kg

### 4.11 Relationship between % fruit infestation in number and yield/ha

The data on % fruit infestation in number were regressed against yield/ha and a negative linear relationship was obtained between them. It was evident from the figure 7 that the equation y = -0.38x + 19.409 gave a good fit to the data, and the co-efficient of determination ($R^2$ = 0.892) showed that, fitted regression line had a significant regression co-efficient. It is evident from the regression line and equation that, the yield increased with the decreased of % fruit infestation in number in different controlling methods of bean pod borer.

### 4.12 Relationship between % fruit infestation in number and yield/ha

Correlation study was done to established a relationship between % fruit infestation in weight and yield (t/ha). From the study it was revealed that significant correlations existed between the characters (Figure 8). The regression equation y = -0.3635x + 18.14 gave a good fit to the data and the value of the co-efficient of determination ($R^2$ = 0.888). From this it can be concluded that % fruit infestation in number decrease the yield.

### 4.13 Relationship between number of flower bud and yield/ha

When the data on number of flower bud and yield per hectare were regressed a positive relationship was obtained between these two characters. Here the equation y = 1.6995x - 14.337 gave a good fit to the data, and the value of the co-efficient of determination ($R^2$ = 0.917) showed that the fitted regression line had a significant regression coefficient. The increase in yield per hectare due to the increase of number of flower bud was justifiable (Figure 9).

### 4.14 Relationship between length of flower inflorescence and yield/ha

The data on length of flower inflorescence were regressed against yield/ha and a positive linear relationship was obtained between the characters. It was evident from the figure 10 that the equation y = 0.5825x - 13.714 gave a good fit to the data, and the co-efficient of determination ($R^2$ = 0.872) showed that, fitted regression line had a significant regression co-efficient. It is evident from the regression line and equation that, the yield increased with the increased length of flower inflorescence.

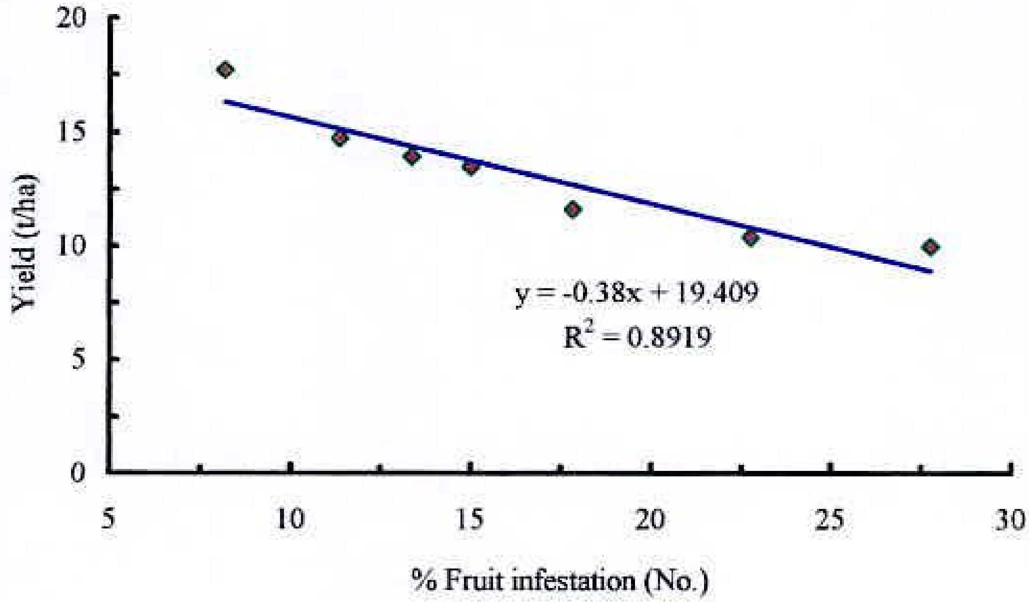


Figure 7. Relationship between % fruit infestation in number and yield as influenced by different control measure in controlling bean pod borer

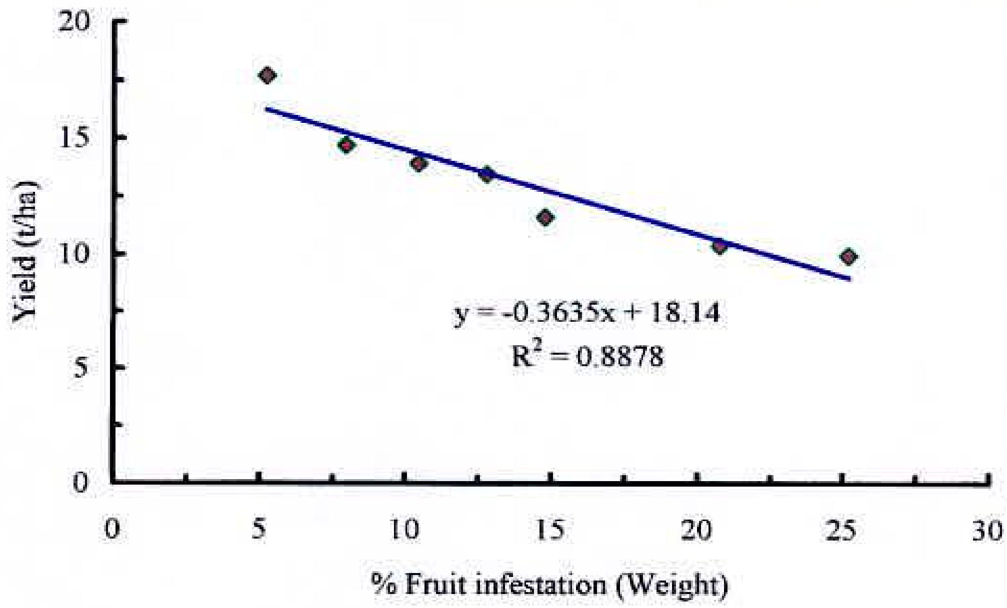


Figure 8. Relationship between % fruit infestation in weight and yield as influenced by different control measure in controlling bean pod borer

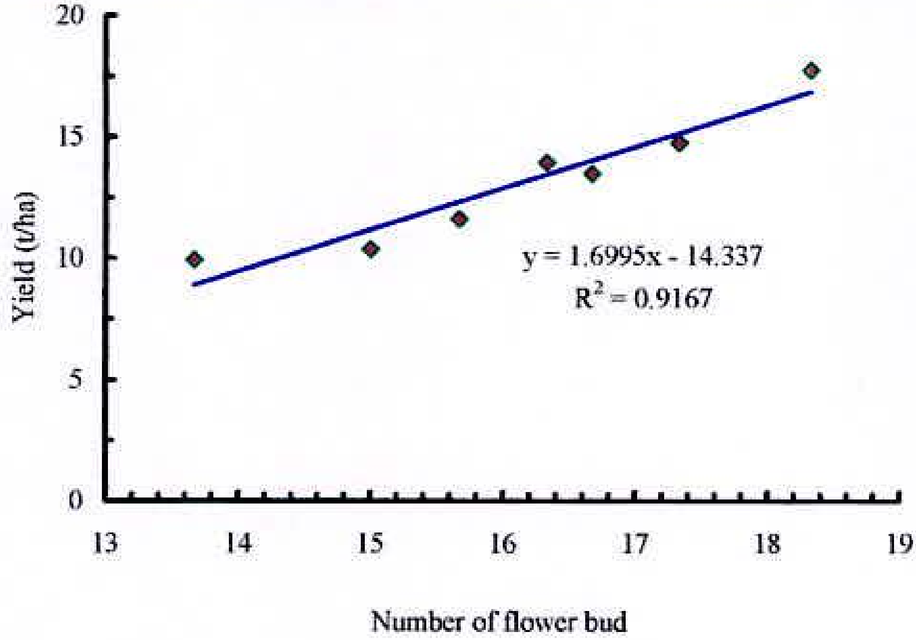


Figure 9. Relationship between number of flower bud and yield as influenced by different control measure in controlling bean pod borer

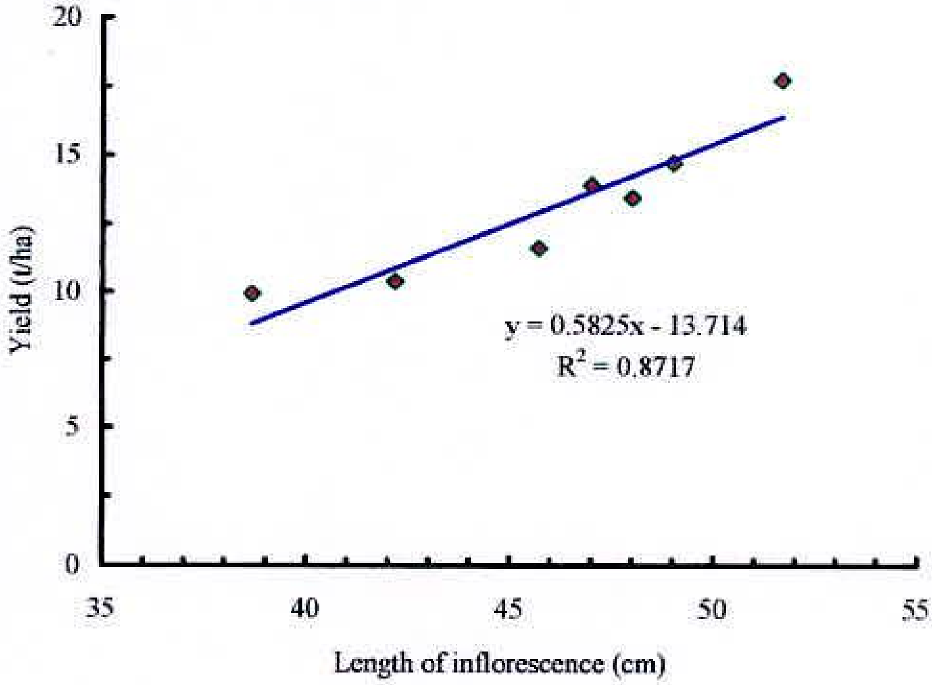


Figure 10. Relationship between length of inflorescence and yield as influenced by different control measure in controlling bean pod borer

# Chapter V

## SUMMARY AND CONCLUSION

Under the present study significant difference was recorded in number of flower bud per inflorescence in different control methods in controlling bean pod borer. The highest number of flower bud/inflorescence (18.33) was recorded in $T_5$ treatment and the lowest number of flower bud/inflorescence (13.67) was recorded in $T_7$. Maximum length of flower bud (51.67 cm) was recorded in $T_5$ treatment and the minimum length of flower bud (38.67 cm) was recorded in $T_7$ treatment. Maximum width of flower bud (6.33 cm) was recorded in $T_5$ and the minimum width of flower bud (5.30 cm) was recorded in $T_7$ treatment.

At early fruiting stage, the highest percent of fruit infestation in number (56.85) was recorded in $T_7$ treatment and the lowest (18.80) was observed in $T_5$ treatment at first harvest. Similar trend of result was observed in the next consecutive harvests at early, mid, late fruiting stage, respectively. By the same way the highest result (106.67) was found in $T_7$ treatment and the lowest (53.33) was observed in $T_5$ treatment in considering the total number of infested fruit. Same result was established in terms of percent of average infested fruit. On the other hand, reverse trend of result was observed in $T_7$ (277.33) and $T_5$ (598.33) treatments in considering the total number of healthy fruit.

On weight basis data related to percent infested fruit performed statistically significant variation. At 1[st] harvest of early fruiting stage the highest percentage infested fruit in weight basis (42.49%) was recorded in $T_7$ treatment. On the other hand the, lowest percentage infested fruit on weight basis (7.15%) was recorded in $T_5$ treatment. Highest and lowest single fruit weight was observed in $T_5$ (11.80) and $T_7$ (8.83) treatments, respectively. Moreover, maximum and minimum length of single fruit was recorded in $T_5$ (11.90cm) treatment and in $T_7$ (9.83cm) treatment, respectively.

Finally, the highest yield per hectare (17.65 ton) was recorded in $T_5$ treatment and the lowest yield per hectare (9.93 ton) was recorded in $T_7$ treatment. Highest benefit-cost ratio (2.89) was recorded in the treatment $T_5$ and negative benefit-cost ratio (-0.51) was recorded in treatment $T_1$.

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

- Any other chemical and botanical insecticides may be used for comparative study among the chemical and botanical insecticides.

- Some commonly available botanical insecticides such as neem leaf extract, tobacco leaf may be used for easily address the poor people of our country.

- Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

# Chapter VI

# LITERATURE CITED


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## APPENDICES

**Appendix I. Results of mechanical and chemical analysis of soil of the experimental plot**

**Mechanical analysis**

| Constituents | Percent |
|---|---|
| Sand | 33.45 |
| Silt | 60.25 |
| Clay | 6.20 |
| Textural class | Silty loam |

**Chemical analysis**

| Soil properties | Amount |
|---|---|
| Soil pH | 6.12 |
| Organic carbon (%) | 1.32 |
| Total nitrogen (%) | 0.08 |
| Available P (ppm) | 20 |
| Exchangeable K (%) | 0.2 |

**Source: Soil Reasearch Development Institute (SRDI)**

**Appendix II. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from September 2006 to March 2007**

| Month | Air temperature ($^0$C) | | RH (%) | Total rainfall (mm) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| September 06 | 26.20 | 24.1 | 73 | 07 |
| October 06 | 26.70 | 21.1 | 89 | 07 |
| November 06 | 24.00 | 20.1 | 87 | 02 |
| December 06 | 21.00 | 20.9 | 64 | 04 |
| January 07 | 20.20 | 21.85 | 74 | 15 |
| February 07 | 20.25 | 18.55 | 71 | 22 |
| March 07 | 22.25 | 19.30 | 75 | 38 |

Source : Dhaka Metrological Center

**Appendix III.** **Analysis of variance of the data on different control methods applied against bean pod borer on number of pod at early fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of fruit/plot at | | | | | |
| | | 1st harvest (10.12.2006) | | | 2nd harvest (24.12.2006) | | |
| | | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation |
| Replication | 2 | 0.048 | 0.143 | 2.571 | 2.476 | 0.333 | 0.084 |
| Treatment | 6 | 16.095** | 9.556** | 462.48** | 284.714** | 14.825** | 429.01** |
| Error | 12 | 0.548 | 0.198 | 4.049 | 3.810 | 0.278 | 2.159 |

** Significant at 0.01 level of probability

**Appendix IV.** **Analysis of variance of the data on different control methods applied against bean pod borer on number of pod at mid fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of fruit/plot at | | | | | |
| | | 3rd harvest (07.01.2007) | | | 4th harvest (21.01.2007) | | |
| | | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation |
| Replication | 2 | 1.190 | 0.143 | 0.283 | 1.857 | 0.190 | 0.372 |
| Treatment | 6 | 709.429** | 20.190** | 78.199** | 735.603** | 14.635** | 152.28** |
| Error | 12 | 6.190 | 0.310 | 0.897 | 5.413 | 0.135 | 0.543 |

** Significant at 0.01 level of probability

**Appendix V. Analysis of variance of the data on different control methods applied against bean pod borer on number of pod at late fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of fruit/plot at | | | | | | | | |
| | | 5th harvest (04.02.2007) | | | 6th harvest (18.02.2007) | | | 7th harvest (04.03.2007) | | |
| | | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation |
| Replication | 2 | 10.333 | 0.190 | 0.180 | 104.62 | 0.143 | 2.589 | 0.048 | 0.190 | 0.233 |
| Treatment | 6 | 1608.75** | 21.492** | 113.02** | 1486.94** | 28.317** | 108.61** | 1750.64** | 33.603** | 61.268** |
| Error | 12 | 10.722 | 0.302 | 0.451 | 10.341 | 0.532 | 0.623 | 12.492 | 1.079 | 0.707 |

** Significant at 0.01 level of probability

**Appendix VI. Analysis of variance of the data on different control methods applied against bean pod borer on number of pod at early, mid, late fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Total number of healthy fruit | Total number of infested fruit | Average number of healthy fruit | Average number of infested fruit | % Average Infestation |
| Replication | 2 | 245.19 | 4.333 | 5.004 | 0.088 | 0.021 |
| Treatment | 6 | 37087.079** | 940.00** | 756.88** | 19.184** | 137.710** |
| Error | 12 | 44.079 | 2.833 | 0.900 | 0.058 | 0.157 |

** Significant at 0.01 level of probability

**Appendix VII. Analysis of variance of the data on different control methods applied against bean pod borer on weight of pod at early fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Weight of fruit/plot (g)at | | | | | |
| | | 1st harvest (10.12.2006) | | | 2nd harvest (24.12.2006) | | |
| | | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation |
| Replication | 2 | 36.05 | 13.369 | 0.953 | 415.43 | 43.429 | 0.525 |
| Treatment | 6 | 1976.08** | 809.718** | 462.256** | 39976.21** | 1097.47** | 269.832** |
| Error | 12 | 76.770 | 9.230 | 5.160 | 641.373 | 12.401 | 1.716 |

** Significant at 0.01 level of probability

**Appendix VIII. Analysis of variance of the data on different control methods applied against bean pod borer on weight of pod at mid fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Weight of fruit/plot (g)at | | | | | |
| | | 3rd harvest (07.01.2007) | | | 4th harvest (21.01.2007) | | |
| | | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation |
| Replication | 2 | 154.476 | 13.440 | 0.040 | 236.05 | 15.155 | 0.276 |
| Treatment | 6 | 85827.16** | 1429.798** | 73.905** | 104980.54** | 1322.290** | 89.698** |
| Error | 12 | 764.754 | 19.440 | 0.677 | 671.99 | 7.224 | 0.205 |

** Significant at 0.01 level of probability

**Appendix IX. Analysis of variance of the data on different control methods applied against bean pod borer on weight of pod at late fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Weight of fruit/plot (g) at | | | | | | | | |
| | | 5th harvest (04.02.2007) | | | 6th harvest (18.02.2007) | | | 7th harvest (04.03.2007) | | |
| | | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation | Healthy fruit | Infested fruit | % infestation |
| Replication | 2 | 1350.75 | 5.012 | 0.040 | 13587.9 | 81.679 | 3.481 | 17.869 | 23.298 | 0.053 |
| Treatment | 6 | 194970.9** | 1683.35** | 73.905** | 219166.8** | 3545.23** | 86.021** | 176109.5** | 4490.75** | 64.963** |
| Error | 12 | 1400.81 | 50.067 | 0.677 | 1427.44 | 43.859 | 0.771 | 1291.68 | 32.631 | 0.358 |

** Significant at 0.01 level of probability

**Appendix X. Analysis of variance of the data on different control methods applied against bean pod borer on weight of pod at early, mid, late fruiting stage**

| Source of variation | Degrees of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Total weight of healthy fruit | Total weight of infested fruit | Average weight of healthy fruit | Average weight of infested fruit | % Average Infestation |
| Replication | 2 | 234.05 | 12.012 | 23.369 | 55.154 | 1.040 |
| Treatment | 6 | 104943.54** | 1623.35** | 815.713** | 1324.29** | 73.905** |
| Error | 12 | 678.91 | 55.067 | 9.452 | 12.224 | 1.645 |

** Significant at 0.01 level of probability

**Appendix XI. Analysis of variance of the data on different control methods in controlling bean pod borer**

| Source of variation | Degrees of freedom | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | No. of the flower bud/inflorescence | Weight of single fruit (g) | Length of single fruit (cm) | Length of the flower bud (cm) | Width of the flower bud (cm) | Yield (t/ha) |
| Replication | 2 | 0.143 | 0.052 | 0.059 | 0.204 | 0.002 | 0.167 |
| Treatment | 6 | 7.095** | 3.048** | 1.615** | 57.295** | 0.349** | 22.016** |
| Error | 12 | 0.476 | 0.082 | 0.034 | 2.149 | 0.017 | 0.031 |

** Significant at 0.01 level of probability