# INTENSITY OF INFESTATION AND MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER *(Leucinodes orbonalis* Guenee) IN KHARIF SEASON



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**MASTER OF SCIENCE**

**IN**

**ENTOMOLOGY**

**SHER-E-BANGLA AGRICULTURAL**

**DHAKA-1207**

**June, 2006**

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**Semester: January-June/2006**



A Thesis

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

**MASTER OF SCIENCE**

**IN**

**ENTOMOLOGY**

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# DECLARATION

I do hereby declare that this thesis entitled *"Intensity of infestation and management of brinjal shoot and fruit bore r(Leucinodes orbonalis* Guenee) *in kharif season "* has been written and composed by myself with my own investigated research data.

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

**June, 2006** **(Ayesha Akter)**

# *CERTIFICATE*

This is to certify that thesis entitled, “Intensity of infestation and management of brinjal shoot and fruit *borer(Leucinodes orbonalis* Guenee) in kharif season” submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in ENTOMOLOGY, embodies the result of a piece of bona- fide research work carried out by Ayesha Akter, Regisrtation NO 01508 under my supervision and guidance No part of the thesis has been submitted for any other degree or diploma

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

**Dated: June, 2006**

**( Prof. Jahanara Begum)**
**Supervisor**
**Advisory Committee**

**DEDICATED**

**TO**

**MY HEAVENLY FATHER.**

# ACKNOWLEDGEMENTS

The authoress deems it a profound privilege to express her enormous sense of gratitude to the Almighty Allah for His countless blessings, support, protection, wisdom, and kind assent to successfully complete her Master of Science Program

The authoress also has much pleasure to express her deepest gratitude and profound regards and indebtedness to her Supervisor and reverend teacher, Jahanara Begum, Professor, Department of Entomology, Sher-e-Bangla Agricultural University,Dhaka, for her planning ,painstaking and scholastic guidance, support, extraordinary kind-concem, ever-lasting encouragement, inestimable co-operation and intellectual criticisms encircling the research work till final preparation of this manuscript

She also desires to express her deep and heartfelt thanks and sincere appreciation to her Co-supervisor, Mr Mohammed Ali, Associate Professor and Chairman, Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, for his paramount contribution, comments, advice, compassionate help and inspiration in all phases of study and research

The authoress is also thankful to all respective teachers, members of the advisory committee. Post Graduate Dean, Vice Chancellor, intimate friends , and well-wishers for their helps in all aspects during her study.

The authoress expressed her deepest and endless gratitude to Md Motiar Rahman, Scientific Officer, Plant Breeding Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, and Mirza Hasanuzzaman ,Lecturer, Department of Agronomy, for their sacrifices, help, inspiration, encouragement in various ways during the study and during the preparation of the manuscript

The authoress also wishes to acknowledge her heartiest indebtedness to her mother, father-in-law and mother-in-law for their relentless inspiration and blessings towards her study and learning Sincere gratitude is extended to her brother-in-law, Chayon and relatives who prayed for her success

Lastly and most importantly, the authoress is grateful to her beloved husband Krishibid Moshiur Rahman Humayun for his good wishes, constant inspiration, encouragement and sacrifices during the study period He saved the authoress from many errors and omissions and helped substantially in preparing the references and checking references Without his ceaseless patience and support, the completion of this work would not have been possible

June, 2006 The Authoress

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# THESIS ABSTRACT

## INTENSITY OF INFESTATION AND MANAGEMENT OF BRINJA1 SHOOT AND FRUIT BORER( *Leucinodes orbonalis* Guence) IN KHARIF SEASON

By
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An experiment was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka, during January to July, 2005 to observe the infestation level and to evaluate the effectiveness of different management practices against brinjal shoot &fruit borer, *Luc inodes orbonalis* Guenee Seven treatments comprising mechanical & cultural control with different combinations of three promising insecticides eg, Sumialpha 5EC, Suntap 50WP and Furdan 5G were tested on a local brinjal variety “Khat khatia” laid out in RCBD with 3 replications Highest infestation of shoot (17%) & fruit (63% by wt & 75% by no ) was observed in the control plot, which was significantly highest from all other treatments. Treatment 6 consisting of mechanical & cultural control + Suntap 50WP @ 1 g/1 & Sumialpha 5EC @ I ml/1 of water at 5% infestation level gave the best performance resulting significantly lowest shoot (6%) & fruit (25%) infestation confirming highest yield (20 96 ton/ha). Treatment 3 -Furadan 5G @ 1.5 kg ai/ha single application + Sumialpha 5EC @ lml/1 of water at 7 days intervals also gave statistically similar results. The intensity of fruit infestation by BSFB was higher at later stages of crop growth for all the treatments

# CHAPTER I
# INTRODUCTION

Vegetables are protective food rich in vitamins and minerals which are essential for maintaining good health Increased production and consumption of vegetables could alleviate the malnutrition and improve nutritional standard of our people

Brinjal, *Solatium melongena* L also known as eggplant and aubergine, is one of the most popular and principal vegetable crops grown in Bangladesh Brinjal,of the family Solanaceae, is rich in calcium, phosphorus, sulphur, chlorine, and vitamins A and C It is a native of India and is extensively grown in all the Southeast Asian countries Brinjal is a warm season crop requires continuous long warm weather during growth and fruit maturation The optimum growing temperature is 22-30° C and growth stops at temperatures below 17° C (Yamaguchi, 1983)

Bangladesh has a serious deficiency in vegetables Though the optimum daily requirement of vegetables for a full- grown person is 285g, yet the per capita consumption is only 32g in this country (Ramphall and Gill, 1990) As a result, chronic malnutrition is commonly evident in Bangladesh The vegetable production in summer is scanty and brinjal plays an important role to cover this lean period

Brinjal is extensively grown in kitchen and commercial gardens in both Rabi and Kharif season in Bangladesh and acceptable to the people of all social status It is the second most important vegetable crop after potato in Bangladesh in relation to its production and consumption Brinjal covers an area of 29,960 hectares, which is about 14 92% of total vegetable area of the country, and its production is about 382000 tons during the year 2000(Anon, 2003)

Brinjal is attacked by 53 species of insect pests among which the most obnoxious and detrimental one is the brinjal shoot and fruit borer (BSFB>, *Leucinodes orbonalis* Ciuenee( Alam and Sana, 1962, Butani and Jotwani, 1984; Nair, 1986; Chattopadhyay, 1987, Tewari and Sandana, 1990) The incidence of the pest occurs either sporadically or in outbreak every year throughout subcontinent affecting the quality and yield of the crop adversely (Alam, 1969, Dhankar, 1988)

Activity of this pest is adversely affected by severe cold but hibernation does not occur and are active in summer months, especially in the rainy season (Kallo, 1988) This pest also attacks potato, tomato peas(Hill,1987) and other solanaceous crops and wild Solanum species(Karim, 1994)

The damage by BSFB starts at seedling stage and continues till the last harvest of fruits. At early stage of plant growth, the larvae bore into petioles and midribs of large leaves and young shoots and plug the entry points with their excreta, feed within (Butani and Jotwani, 1984) and cause drooping and withering of shoot (Alam and Sana, 1962) At a later stage of plant growth, the larvae bore into the flower buds and fruits through calyx without leaving any visible sign of infestation (Butani and Jotwani, 1984) Secondary infections by certain bacteria cause further deterioration of the fruits and the fruits become unfit for human consumption (Islam and Karim, 1994)

Incidence of BSFB in brinjal could cause damage as high as 12-16% on shoots and 20-63% on fruits depending on different brinjal varieties, lacations, and seasons

(Alam, 1969) The colossal yield loss caused by this pest has been estimated up to 67% in Haryana, India (Dhankar, 1988)

Considering the seriousness of the pest a wide range of organophosphorus , carbamates and synthetic pyrethroids with various spray formulations have been advocated from time to time against this pest (Banerjee and Basu, 1952; Satpathy, 1968, Lai,1973; Ayvanna et al 1976; Metho and Lall, 1981, Yardani, et al 1981; Yein, 1985; Parkash, 1988)

But the research on the environmentally friendly different alternative non chemical approaches like cultural, mechanical, biological, host plant resistance, etc undertaken by the researchers throughout the world is fragmentary Thus,the use of chemical means still vital and provide a rapid ,cost-competitive and typically effective tool to combat this pest although in many instances the insecticides do not yield good control

The main reason, perhaps, the careless and frequent indiscriminate use of insecticides may have caused developing resistance against the pest worldwide Evidences of pest resurgence are also not very uncommon now-a-days Besides, the cost of cultivation has increased tremendously, the environment has become polluted and, man, animal, fish,wildlife and other beneficial micro flora and fauna have been affected It has been documented that 70% farmers of greater Jessore region of Bangladesh spray insecticides to brinjal at every alternate day and thus 81-84 sprays are applied in a single season (Anon, 1994a) The question of retention of residual toxicity of pesticides in brinjal is yet another big threat to our vegetable exports in the foreign market s( Islam, 1999)

It is,therefore, a national demand to find out the best-suited control measures including chemicals for managing this pest at desirable level These types of approach have not yet been studied except few sporadic researchers Bangladesh Agricultural Research Institute (BARI) is trying to find out suitable integrated approaches to combat this pest(Anon, 1994b) The possibility of suppression of this pest by cultural method, clipping of infested shoots, use of kerosene, neem oil and botanicals, grafting seedling on wild Solanum and use of selective chemicals are some of the new and unexploited approaches.

As no other suitable non- chemical control measures against this pest are available, the best treatment develop through this study is expected to be an economically sound to combat this pest with maximum return Moreover, escape from such undesirable adverse effect of pesticides, judicious use of chemical insecticides may still be considered as a prime weapon

Therefore, in the present study some treatments consisting of combinations of various cultural, mechanical and chemical control methods were considered.

**The objectives of this study are**

a) to determine the intensity of infestation of Brinjal shoot and fruit borer during Kharif season and,

b) to develop a suitable combination of tactics for the management of the pest

# CHAPTER II

# REVIEW OF LITERATURE

Brinjal, *Solatium melongena* L is one of the most common and popular vegetable crops in Bangladesh The brinjal is attacked by as many as 53 species of insect pests (Nayar et al 1995) Of these, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee, is the most serious one causing significant damage to crop The incidence of this pest occurs sporadically or in epidemic form every year throughout Bangladesh and affecting adversely the quality and yield of the crop The damage caused by this pest varies from 12-16% in shoot and 20-63% in fruits (Alam et al 1964) and as a whole up to 70% loss is caused to the crop(Nair, 1986) For the management of BSFB,two methods are used in Bangladesh so far One is the clean cultivation with removal of infested shoots and fruits The other is the application of synthetic organic chemicals at 7-15 days interval, which still remains main weapon Literature regarding its management by utilizing IPM packages consisting of various non-chemical control measures like cultural, physical,biological, etc are rare and limited Review of the available literatures relevant to the present study including the target pest and its management is presented below under the following sub-headings

## Origin and distribution of brinjal shoot and fruit borer(BSFB)

The genus *Leucinodes* was first established by Guenee in 1984 and *Leucinodes e/eganlaJis* was used as the type species from South America The genus includes three

***orbonalis*** Guenee, ***L. diaphana*** Hampsn and ***apicahs*** Hampsn(Alam et ***lucintxies orbonalis*** is native to India but occurs in the Indian Sub- ndaman Is , India. Pakistan, Nepal, Bangladesh and Sri Lanka), Far-East Asia £, China, Taiwan and Japan), Africa(Burundi, Cameroon, Congo, Ethiopia, >tho, Kenya, Malawi, South Africa, etc )(Veenakumari ***et al.*** 1995) and Saudi n, 1982) Eggplants are severely attacked by shoot and fruit borer in the lot in the temperate zone

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ot and fruit borer is the most destructive pest of brinjal(Alam and Sana, 1969; Butani and Jotwani, 1984, Nair, 1986 and Chattopadhyay, 1987) It found to attack shoots and fruits of tomato (Das and Patnaik, 1970), ***num tuberosum*** L ), green peas(/[J]/.v//m ***sativum*** L )and ***Solanum torvum*** /al,1997 and Hill, 1987) Other wild species of Solanum are also attack,ed by Carim, 1994). lsahaque and Chaudhury (1983) reported ***Solatium nigram S. torvum, S. myriacanthum*** and potato as alternate host plants of BSFB in

; and Patnaik (1970) studied that ***Leucinodes orbonalis*** Guenee, a serious pest ***Solanum me/ongena),*** was also observed to bore into the shoots and fruits of Bhubaneswar, India The insect was found to be able to complete its nt on tomato and also on the weed ***S.nigrum,*** but moths that had been reared :r were smaller and laid fewer eggs than those reared on tomato or brinjal species, *L. orhonalis* Guenee, *L. diaphana* Hampsn and *L. apical is* Hampsn(AIam et al 1964) *Ieucinodes orhonalis* is native to India but occurs in the Indian Subcontinent! Andaman Is., India. Pakistan, Nepal, Bangladesh and Sri Lanka), Far-East Asia (Hong Kong, China, Taiwan and Japan), Africa(Burundi, Cameroon, Congo, Ethiopia, Ghana, Lesotho, Kenya, Malawi, South Africa, etc )(Veenakumari *et al.* 1995) and Saudi Arabia(Anon, 1982). Eggplants are severely attacked by shoot and fruit borer in the tropics but not in the temperate zone

## Host range

Shoot and fruit borer is the most destructive pest of brinjal(Alam and Sana, 1962,Alam, 1969, Butani and Jotwani, 1984; Nair, 1986 and Chattopadhyay, 1987) It was also found to attack shoots and fruits of tomato (Das and Patnaik, 1970), pot*&\o(Solanum tuberosum* L ), green peas*(Pisum sativum* L )and *Solatium torvum* Swartz( Atwal, 1997 and Hill, 1987) Other wild species of Solanum are also attack,ed by this pest (Karim, 1994) Isahaque and Chaudhury (1983) reported *Solanum mgram S. indicum, S.torvum, S. myriacanthum* and potato as alternate host plants of BSFB in Assam

Das and Patnaik (1970) studied that *Leucinodes orhonalis* Guenee, a serious pest of brinjal (*Solanum melongena),* was also observed to bore into the shoots and fruits of tomato in Bhubaneswar, India The insect was found to be able to complete its development on tomato and also on the weed *S.nigrum,* but moths that had been reared on the latter were smaller and laid fewer eggs than those reared on tomato or brinjal

## Nature of damage

The attack of *Leucinodes orbonalis* usually starts after transplanting and continues till the last harvest of the fruits Their eggs are laid singly and deposited on the ventral surface of the leaves, shoots, flower buds, and petiole and occasionally on the fuit In young plant, the larvae bore into petioles and midribs of large leaves and also bore into the young shoots Immediately after boring the larvae plugged the entry hole with frass and feed inside (Butani and Jotwani, 1984) When the flower buds come out, the larvae also bore into it This kind of damage retards the growth of the plant and delays the formation of flowers and fruits The time taken for the newly hatched larvae to move into the shoot is 3-4 hours (Alam and Sana, 1962) As the larva grows older it goes deeper into the heart of shoot The infested shoot droop or wilt due to disruption of the vascular system and translocation of food materials (Alam and Sana, 1962) When the food materials of the affected shoots run short, the larva then attacks the fruits where food materials are abundant At the fruiting stage, the larvae bore generally through calyx, flower buds and the fruits without leaving visible sign of infestation and feed inside the fruit (Butani and Jotwani, 1984) The infested flower buds dry and shed The infested fruits show exit holes along with excreta During fruiting period, the infestation of fruits are greater than that of the shoots because they prefer fruit than shoot (Alam and Sana, 1962) The larvae feed on the pith tissues of infested fruits by boring tunnels When an infested fruit is cut open, dark excreta, mould and sometime rotten portion is found The affected fruits become unfit for human consumption and marketing

The ftjll-grown larvae come out through the exit whole and drop on the ground for pupation in the soil or plant debris. The pest is reported to cause 1-16% damage to shoots and 16-64% to fruit in Bangladesh (Butani and Jotwani, 1984) Peswani and Ratan Lal(1964) reported that this borer damaged 20 7% fruits and if only damaged portion of these fruits is discarded, the loss in weight comes to 9 7%. The yield loss varies with location and season and greatest when temperature and humidity is high Losses range from 20-60% (Dhanker, 1988, Roy and Pande, 1994) or even higher (Lai, 1991)

## Seasonal abundance

The seasonal history of BSFB varies considerably with varying climatic conditions throughout the year Hibernation does not not take place and the insects are found to be ative in summer, especially in rainy season The population of *Leucinodes orbonalis* Guenee began to increase from the first week of July and peaked (50 larvae per
2 m row) during the third week of August The population of the pest was found to be positively correlated with average temperature, mean relative humidity and total rainfall ( Shukla. 1989) There are altogether five generations of the pest in a year of w hich three of them occur during May to October and two from November to April During summer each generation covers about four to six weeks but in winter it covers up to sixteen weeks (Alam, 1969).

Pawar *et a/.* (1986) found in India that the infestation of shoot began 30 days after transplantation with peaked in the second week of September and declined on the l$^{sl}$ week of November The fruit infestation began 3$^{ul}$ week of September with a peak in the 2$^{nd}$ week of November In summer, shoot infestation began from the 3$^{rd}$ week of January and the infestation reached a peak in the 2'$^{ut}$ week of February while fruit infestation peaked in the 1"' week of April

## Biology

L *orbonalis* belongs to order Lepidoptera, Family Pyralidae The adult moth of BSFB is white, small and cryptic in nature(Alam, 1969) measuring 22-26mm long at wing expansei Butani and Jotwani, 1984) Longevity of adult female is 2 75-8 00 days and 1-4 days(Baang and Corey, 1991) There are two pairs of well-developed membranous wing with conspicuous black and brown patches and dots Fore pair of wings are longer and broader than the opalescent hind pair with the black dots along the margin (Butani and Jotwani, 1984). The margin of both wings are provided with tine bristle like hairs Mating takes place in the second night after emergence,

The egg is laid singly and deposited on shoots, flower buds, petioles and on the ventral surface of the leaves Eggs are laid during the later part of the night and continues till the early hours in the morning (Alam, 1969) The number of eggs laid by a single female varies from 11-68 with an average of 42 (Alam and Sana, 1962; Atwal. 1977) But, Butani and Jotwani (1984) reported that a female lays an average of 250 eggs The egg measure an average of 0 44mm X 0 32mm with creamy white colour and change into yellow to yellowish orange as the development proceeds ( Alam *et al.* 1964) Incubation period varies from 3 to 5 days during summer and 7-8 days in the winter ( Alam and Sana, 1962; Butani and Jotwani, 1984)

After hatching the young larvae measuring 1 49 mm X 0 41 mm with slender abdomen tapering posteriorly looks dull white in colour with yellowish tinge which later turn into creamy white( Alam et al 1964). The full fed larvae measures 16.3 mm X 3 16 mm in its widest part The body is light pinkish in colour with creamy tinge The thoracic and first three abdominal segments are more pinkish than those of the rest (Alam *et al.*

1964) After hatching, the larvae search for a suitable place on the host for boring During the fruiting stage of the plant, the larva prefers fruits than the shoots or others parts of the plant A larva may destroy 4-6 fruits during its larval period (Atwal, 1997) The larva passes through 5 instars Larval period varies from 12-15 days duing the summer and 14- 22 days in winter The full-grown larva passes through a pre-pupal period of 3-4 days (Alam and Sana, 1962; Butani and Jotwani, 1984) Sandanayake and Edirisinhhe (1992) observed that the I$^{st}$ instar larvae occurred in flowers, while 2$^{nd}$ instar larvae were present in all susceptible parts of the plant Larvae were confined to the shoots and fruits in their 3$^{rd}$ and 4$^{lh}$ instars, while 5$^{lh}$ instar larvae were found only in the fruits The size of entry hole made by a larva was found to be a good indicator of its instar

The full-grown larva comes out from the infested shoots or fruits through their feeding tunnel and pupate in ground litter usually 1-3 cm below soil surface within a boat-shaped, tough silken cocoon (Yin, 1993). During rainy season pupation takes place on the stems or shoots or the dried leaves of the plants (Alam, 1969) The pupa is capable of surviving in temperature as low as -6.5 C (Lai, 1975) The full grown pupa measures 6.4mmX 1 66mm The anal segment of the male pupa is devoid of bristles, where as the female pupa has eight bristles with incurved tips at the anal segment (Alam and Sana, 1962). The pupal period varies from 7-10 days during summer and 13-15 days in the winter (Butani and Jotwani, 1984)

The total life cycle of this pest is completed by 34-59 days with five or more overlapping generations per year ( Alam, 1969 and Atwal, 1997) Yin (1993) observed 1- 6 generations in a year with overwintering pupa

## Management of brinjal shoot and fruit borer

## Cultural practices

Cultural control is the deliberate manipulation of the environment to make it less favourable for the pest by disrupting the reproductive cycle, eliminating their foods or by making it more favourable for their natural enemies Cultural practices are considered important to suppress pest population in the integrated pest management programmes (Brader, 1979) Cultural methods like clean cultivation, destroying crop residues and alternate host, use of balanced fertilizer, shifting of planting or harvesting time, crop rotation, etc are known to be useftil for the management of brinjal shoot and fruit borer infestation( Karim, 1994)

## Mechanical practices

## Hand picking and clipping of infested plant parts

Removal of infested shoots and fruits along with the larvae and destroying them mechanically may help in reducing BSFB population in the Field Mechanical elimination of infested shoots and fruits could be an effective 1PM technique This technique when complemented with spray of chemical insecticides gave satisfactory result as compared with sprays of chemical insecticides alone (Anon, 1994a) Ganguli *et* a/ (1971) obtained 6 45 times higher yield from the plots where infested shoots were removed by hand

Hand picking of infested shoots and fruits, and dusting ash on leaves to manage the brinjal shoot and fruit borer was tested as a component of 1PM The results obtained were that the damaged fruit per plot greater in plots with single picking than those with frequent picking in India (Verma, 1986) Treatment by mechanical destruction of infested shoots and fruits with larvae resulted in very good control of shoot and fruit borer as compared to control (Sasikala *el al.* 1999)

Total yield varied significantly and significant yield increase was obtained due to hand picking + spray of suntap over untreated control treatment It indicated that mechanical means along with chemical spray might be worthy for the management of brinjal shoot and fruit borer (Anon, 1993)

## Use of chemical fertilizer

Application of chemical fertilizer was found to have some positive or negative effect on the incidence of BSFB An increased dose of nitrogen and phosphorous manifested heavier infestation while higher dose of potassium resulted in lighter infestation of BSFB in Haryana, India (Caudhury and Kashyap, 1987) Mehto and Lall (1981) also observed similar nature of results

## Host plant resistance

Host plant resistance means the ability of a crop plant to avoid, tolerate or recover from the attack of insect under condition that would cause greater injury to other plants of the same species (Snelling, 1941) For the management of BSFB. resistant or relatively tolerant varieties of eggplant may be used as one of the components of 1PM (Anon, 1994b) Cultivation of resistant varieties can ensure the minimum use of pesticides and therefore save the environment i.e., natural enemies, health, soil micro flora and fauna, etc

The dense pubescence of the leaves of cultivars Elokeshi, Giant Banaras, Black and HI65 made them unsuitable for the adult moth to deposit their eggs and the young larvae after hatching cannot bore easily (Panada and Das, 1974) Ranjeet *et at*Y1995) evaluated 41 cultivars of brinjal in India for two consecutive years 1992 and 1993 where Arka, Kusumakar and Pusa Purple Round were found to be resistant against BSFB

Kabir *et al.* (1984) tested 12 eggplant varieties in Bangladesh and reported that the degree of resistance varied significantly The variety Singnath had the lower rate of shoot infestation and also gave the highest yield while Muktakeshi had the highest rate of infestation Baksha and Ali (1982) found that out of 13 eggplant cultivars none was found resistant to BSFB Moderately tolerant varieties to shoot infestation were Baromashi, Jhumki, Indian andl Bogra Special and to fruit infestation were Noyankajal, Singnath, Japani, Jhumki and Baromashi Tolerance to both shoot and fruit infestation was highest in Jhumki, India and Baromashi,

Although a large number of cultivated varieties of eggplant and related wild species have been screened against the brinjal shoot and fruit borer under natural and green house condition in India and Bangladesh but no variety or cultivar was found to confer resistance consistently (Kallo, 1988 and Anon, 1994b)

Hossain *et al.* (2002) screened resistant brinjal varieties and lines against BSFB in Bangladesh They observed the resistance level of 12 varieties and lines in field condition and found the following order of intensity of BSFB infestation Nayankajal>B L095>B L085>B L098>B L01 14>Khat Khatia-2 >Borka >Laffa > lslampun->BL045>Dhohazan-2>BL0101>Dhohazan-l>KhatKhatia- 1 >BL096> Sadaball>Singnath>Uttara>Baromashi>Jhumki. They also stated that highest percentage (32.89) of BSFB infestation was at 70 DAT and lowest (5 18) was found at 40 DAT The rate of infestation gradually increased with the increase of plant age and then decreased in 100 DAT

## Biological control/Natural enemy

Although numerous predators and parasitoids are identified as biocontral agents of many insect pests but only few have been found to control BSFB So far little success has been achieved for the management of BSFB using these natural enemies Alam (1969) recorded mortality of the larvae of BSFB due to fungus and black ant, *("omponotus compressus* Fb Pupal mortality was also being observed due to the attack of ichneumonid, *Cremastus(=Tralha/a) flovo-orbitalis* Cam parasitoid during the rainy season Alam and Sana (1962) observed that after hatching from eggs, the parasitoid maggot feeds on the endocarp of the fruits and secrete an offensive smelling fluid which probably makes the fruit borer rotten This secretion affects the growth of the larvae and as a result, the larva shrinks and ultimately dies The mortality of adult moths occurred by the attack of predatory black ant, *Camponotus compressus* Fb and excessive rainfall during summer

The larval ecto-parasitoid, Bracon sp was found attached to the thorax of the host *(!.. orhonalis)* larva in Karnataka, India It pupated in a silken cocoon

A pupal parasitoid , *ltamoplex* sp was reported from Kulu Valley , Himachal Pradesh, India where the winter temperature drops as low as -8$^{(,}$C The parasitoid emerged from 9-15% of the larval cocoon of BSFB *ltamoplex (Cruptus)* sp was also recorded attacking a range of Lepidopteranian cocoon (Verma and Lai, 1985)

Mallik *et al.* (1989) reported that *Trathala flavo-orbitalis* Cam parasitizes the BSFB Parasitism increased the host pupal period to I 1 to 18 days, as compared to 6-14 days for healthy pupae, and parasitism varied from 3 57 to 9 06% . *Trathala flavo- orbitalis* is recorded from *L. orbonalis* in India and also in Sri Lanka where *L.orbonalis* is its major host and where an average parasitization level of 36 2% has been reported (Sandanayake and Ldirisinghe, 1993) In Bihar, India *Trathala* was the only parasitoid of *T.orbonalis* with level on attack on larvae ranging from 13 2 to 18 2% in winter to 12.9% in summer in the time when 95 2% of fruit was infested (Naresh *et al.* 1986) *Trathala flavo-orbitalis* is identified as an effective larval parasitoid against BSFB in Bangladesh The rate of parasitism varied from 20 to 25 (Anon, 2001)

A species of *Phanerotoma* near *P. he ndecasi sella* and ( *ampyloneura* sp , are recorded for the first time as parasites of larvae of *L. orbonalis* The parasites were found attacking larvae infesting eggplant near Bangalore, Karnataka, India in July in 1982 Combined parasitism was only 1-2% (Tewari and Krishnamoorthy, 1985)

*Pristomerus testaceus, Temelucha flavo-orbitalis ,Shirakia schoenobii, Microbracon greeni, and Pseudoperichaeta spp , have been reported as pupal parasitoid from India (Butani and Jotwani, 1984) Alam(1969), Das(1984), and Das and Islam (1984) reported that Cremnstus ( Trathala) flavo-orbitalis, Epitranus areolatus, K. giganticus, E. indicus, E. melongemis, E. rossicorpus and Pristomerus testaceus as the parasitoids of BSFB while black ant , Camponotus compressus Fb and spiders as predators*

## Use of hotanicals

Khorsheduzzaman *et at.* (1998) reported that neem oil@ 30 ml/1 of water can provide 41 11% infestation reduction over control by the brinjal shoot and fruit borer The neem oil provided 49 1% brinjal shoot and fruit borer infestation reduction over control Chitra *et al.,(*1993) reported that extract of leaves of *Argemone mexicana* (0 1%), leaves of *Azadirachta mdica(0* 1 %) and Neemguard (0 5%) gave 76 18%, 69 55% and 55 92% control, overuntreated control, respectively

## Sex pheromone as a pest management technique

Das and Islam (1984) reported that the field traps baited with virgin female moths of the brinjal shoot and fruit borer, *Leucinodes orhonalis* Guenee, attracted both marked and wild males.

The chemicals responsible for the attraction of the BSFB adult males were identified and synthesized chemically as (E)-l 1 hexadecenyl acetate( major component) and (E)-ll hexadecen-1-o 1 (minor component) in China and Sri-Lanka The attractiveness of a synthesized form of the acetate was equal to that of the natural extract in laboratory bioassay but in the field trial in Sri Lanka, the synthesized form attracted fewer males than these attracted by the live virgin females (Zhu *et al.* 1987, Attygalle *et al.* 1988)

## Chemical method

Chemical insecticides are the most powerful tools available for the management of insect pests. Insecticides are highly effective, rapid in curative action, adaptable to most situations and relatively economical Insecticides is the only tool for pest management, which is reliable for emergency action when insect pest populations approach or exceed the economic threshold level Since no other dependable control measure of the pest is available, chemical control measure has remained as the key for the control of this pest Wide ranges of insecticides ( organophosphorus, carbamates and synthetic pyrethroids) and varying spray formulations have been advocated from time to time against the BSFB (Yein, 1985; Parkash, 1988, Yardani *et al.* 1981)

Plots of MDUI eggplant seedlings were sprayed with 1 to 4 synthetic pyrethroids (Clocythrin [lambda cyhalothrin] , cypermethrin, deltamethrin and ARC SP03 f of unstated composition]) and 2 conventional insecticides ( monocrotophos and endosulfan) at biweekly intervals from 40 days after transplanting The number of plants infested with shoot and fruit borer was recorded 1 day before and 14 days after each spray All treatments significantly reduced shoot infestation, with sprays of Clocythrin at 31 5-50 0 ppm and deltamethrin at 20 ppm providing complete control The lowest fruit infestation resulted from treatment with 65 6 ppm Clocythrin All pyrethroids significantly increased healthy fruit yield with 25 ppm Clocythrin producing the best yield (15967 kg/plot) The conventional insecticides performed less well (Rajavel *et al.* 1989) Mathirajan *et at.* (2000) assessed that lamda-cyhalothrin applied @ 30g a i /ha was more effective against BSFB than endosulfan and fenvalerate

Agnihotri *et al.* (1990) studied the effectiveness of cypermethrin, fenpropathrin, carbaryl and deltamethrin respectively and evaluated against A. *orbonalis* on two cultivars of eggplant, Pussa Kranti and Pusa Purple Long Cypermethrin (0 01%) and deltamethrin (0.00125%) were the most effective They found the residues on market size fruit declined to <0 01 ppm within 8 days for all insecticides except cypermethrin when applied at >0,005% , which left 0.03-0 04 ppm

Cypermethrin 10EC or cyfluthrin 50EC or fenvalerate 20EC @ 0 5ml per liter of water was found to be effective in controlling the BSFB in Bangladesh when 3 to 4 sprays of any of the above insecticides were applied on plants at 15 days intervals, starting from the first flowering (Anon, 1991) Islam and Quiniones (1990) reported that endosulfan was superior (7.5%) to methyl parathion (10 8%) in controlling the BSFB compared with the control plots (17 9%) with an increased yield of 87.7% and 52 2% by weight , and 79.3% and 50 7% by number respectively over the control

Islam and Karim (1993) reported that eight synthetic pyrethroids and one organophosphate tested against BSFB had insignificant effect in reducing the pest population Although the insecticides were applied at the peak of adult emergence at an interval of not less than 21 days commencing from its first incidence They also reported that the intensity of BSFB infestation in insecticide treated plots was as high as in control plots This signals the possibility that the BSFB may have developed resistance against these insecticides

Field trials of cypermethrin (0 01%) , fenvalerate (0 01%), endosulfan (0 05%) and carbary 1(0 2%) alone at half concentration mixed with Neemark( extract of *Azadunchta indica*) (0.5%) against the BSFB were carried out in Maharashtra, India in 1990-91 (Temurde et al 1992) They found that all that synthetic insecticides gave better control and higher yield than Neemark alone Mixing Neemark with cypermethrin or fenvalerate gave better control of the pest than did Neemark itself

Reddy and Joshi (1990) carried out a field experiment in Madhya Pradesh, India during 1980-81, to find out the etYectiveness of carbaryl(0 2%), dimethoate (0 05%), monocrotophos (0 04%), phosalone(0 05%) and endosulfan (0 07%), alone in combination with Planofix[ NAA] (lOOppm) on the growth and yield of eggplant They found that all combined treatmants increased plant growth and fruit set Carbaryl or endosulfan combined with the plant growth regulator gave the best yields

The various admixture of plant extract and synthetic insecticides were also found to be highly effective against BSFB in inhibiting their feeding The antifeedent produced by Cymbush increased from 3 5 to 711% when mixed with neem while Decis which by itself did not exhibit significant antifeedend effect (17%) but caused by 67 6% feeding inhibition when combined with neem in India (Facknath, 1993 and Chowdhury *et al.* 1993)

A three year study was carried out at Bangladesh Agricultural Research Institute(BARI), Joydebpur, Gazipur , Bangladesh to evaluate the efficacy of some insecticides to control the BSFB *L. orbonalis* G , carbofiiran 3G @ 30kg/ha showed the highest level of efficacy Among the other treatments cypermethrin 10EC was found to be effective against the pest (Chowdhury et al 1993) Misra (1993) reported that frnvalerate 0 05 kg a i/ha, cypermethrin @ 0 05kg a i/ha and deltamethrin @0 007 kg a i /ha are the best suitable insecticides for controlling the BSFB economically

Five new insecticides were tested at BARI, Gazipur against BSFB, among them, FencordlOEC @ 2ml/l of water, Fentox 20EC @ 0 5ml/l of water and Kuridin 5G @ lOkg/ha reduced more than 80% infestation over control and also produced higher yield (Anon, 2001)

## Insecticide resistance

Insecticides Ralothrin IOEC, Sunfuran 36EC, Fenom 10EC, Selecron 50EC, Fastac 2EC, Arrivo 10EC, Shobicron 425EC, Cymbush 10EC, Ripcord 10EC and Nogos 100EC were tested over three consecutive cropping seasons at Gazipur and Jessore districts of Bangladesh against the BSFB but none of the tested insecticides had significant effect in reducing the pest population This signals the possibility that the BSFB has developed resistance against the tested insecticides (Kabir *et al* 1994) In a recent study Kabir *et al* ( 2001) found that BSFB has developed multiple resistances and the distribution of resistance was found to occur countrywide

## Integrated pest management

It is very unlikely that any single method can achieve an acceptable level of control of BSFB thus an integrated approach should be adopted Khorsheduzzaman *et al.* (1998) reported that mechanical control with neem oil and Cymbush applied alternately at 7 days intervals gave the lowest fruit infestation (13 49%), which was followed by grafted plants with mechanical control+ Cymbush at 5% AT (18 07%) and mechanical control + neem oil sprayed at 7 days intervals (22 68%) while the highest fruit infestation (45 54%) was found in the untreared cintrol treatment

Rahman *et al* (1996) obtained reduced rate of shoot/ fruit infestation and increased yield by utilizing the package consisting of Cymbush 10EC sprayed on grafted eggplant and mechanical control on grafted eggplant *Solanum torvum* was used as rootstock for grafting eggplant Similar results were also obtained using grafted brinjal plants at early and mid fruiting stage

Islam *el al* \ 1999) reported that application of insecticide atlOc AT or peak of adult emergence could reduce the number of insecticide application, in the benefit-cost ratio (BCR) and also affect less on the Hymenopterous parasitoid wasp increase Maleque *et al.* (1998) also reported that mechanical control + Cymbush 10EC @ 5% AT produced higher yield and benefit-cost ratio

IPM package comprising hand picking of infested shoots and fruits, dusting ash or application of insecticides and hand picking of infested parts were not found effective in reducing the BSFB infestation But the possibility of suppression of the BSFB by cultural method, use of kerosene oil, botanicals, grafted seedling on wild Solanum and use of selective chemicals may be explored (Anon, 1995) The cause of reduced incidence of the BSFB on grafted eggplant is not clear But it was possible that there may be some translocated substance toxic to the borer from rootstock to the borer from rootstock to the scion

Alam *el al.* (2003) conducted 1PM trials at Jessore and Noakhali in Bangladesh during summer 2002 They compared the efficacy of 1PM package consisting of sanitation i.e. prompt removal of pest-damaged shoots and fruits, and trapping of male moths using sex pheromone with farmers BSFB management practices (insecticide spray at everyday or every alternative days) They portrayed that the shoot infestation as well as fruit infestation in the IPM trials was very much less than the farmers' field

## Action threshold (AT)

Since the farmers use insecticides indiscriminately and even in extreme case every alternate day, the AT has been established in order to reduce the number of insecticide application, their cost, environment pollution, development of resistance , toxic residues on plants, etc

Tewari and Rao (1989) have set a 6% fruit infestation as the AT for the brinjal shoot and fruit borer in Bangalore, India

Islam and Karim (1994) reported that mechanical control plus spray of cypermethrin and monocrotophos alternately at 5% fruit infestation level or spray of cypermethrin alone at weekly intervals provided effective control of the brinjal shoot and fruit borer While standardizing AT for the brinjal shoot and fruit borer, Islam and Karim (1994) also recorded that a 10% AT spray with cypermethrin @ 1 ml/1 of water gave the higher benefit-cost ratio

# CHAPTER HI

# MATERIALS AND METHODS

The present study on the intensity of infestation and management of brinjal shoot and fruit *borer(Leucinodes orhonalis* Guenee) in kharif season consisting of different control measures was carried out at the Sher-e-Bangla Agricultural University (SAU) , Dhaka ,Bangladesh during April to July, 2005 Procedures and application of different control measures are discussed below under the following sub-headings

## Experimental Site

The research was conducted at the Experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from January to July,2005 The experimental field is located at 90°335' E longitude and 23° 774' N latitude at a height of 9 meter above the sea level (BCA, 2004) The land was medium high and well drained

## Climate

The experimental site is situated in the sub-tropical climatic zone characterized by heavy rainfall during the month from April to July during study and scattered rainfall during the rest of the year Monthly maximum and minimum temperature, relative humidity and total rainfall recorded during the period of present study at the SAU experimental farm have been presented in Appendix 1

**Soil**

The soil of the study is silty clay in texture The area represents the agro- ecological zone of 'Madhupur Tract (AEZ NO 28) Organic matter content was very low (0 82%) and soil PH varied from 5.47-5.63.

## Design of experiment

This study was conducted in the field with some control measures including a schedule spray and a control laid out in a Randomized Complete Block Design (RCBD) having 3 replications

## Land preparation

The soil of the experimental field was well prepared by ploughing, harrowing and followed by cross ploughing and leveling The whole field was divided into 3 blocks of equal size and each block was sub-divided into 7 plots (2m X 1.5m ) Nine brinjal (variety Khatkhatia) seedlings were planted in each plot at a distance of 75 cm between lines and 50cm between plants

Cowdung and other chemical fertilizers were applied as recommended by Rashid (1999) for brinjal cultivation @ 15 tons of cowdung and 250, 150 and 125 kg of Urea, TSP and MP, respectively per hectare The half of cowdung and TSP were applied as basal dose during land preparation The remaining cowdung, TSP and,one-third of MP were applied in the pits at transplantation of brinjal seedlings The entire dose of urea and the rest of MP were applied as top dressing The first top dressing of urea (one third) was made at 15 days after transplanting One third of urea and one-third of MP at the time of flower initiation and rest of urea and MP at the time of fruit initiation were applied to keep the plants at normal growth and production

## Raising of seedlings and transplanting

Brinjal seeds (variety: KhatKhatia) were collected from East West Seed (Bangladesh) Ltd , Bashon, Joydebpur, Gazipur A small seed bed measuring 5m X lm was prepared and seeds were sown on 1^M January, 2005 Standard seedling raising practice was followed ( Rashid, 1999) The plots were lightly irrigated regularly for ensuring proper and development of the seedlings The seedbed was mulched for ensuring seed germination, proper growth and development of the seedlings Fourty days-old (3/4 leaf stage) healthy seedlings were transplanted on 10',h February,2005 in the experimental field A total 189 seedlings were transplanted in 21 plots at the rate of 9 seedlings per plot

## Cultural operation

After transplanting light irrigation was given to each pit Dead or damaged seedlings were replaced immediately by new ones from the stock Any damaged seedling was replaced Supplementary irrigation was applied at an interval of 2-3 days Propping of each plant using bamboo sticks (lm height) was done for providing extra support to avoid lodging of the plants Weeding and mulching were given whenever necessary The MP and urea were top dressed in 3 splits as described earlier

## Treatment for Control Measures

The comparative effectiveness of the following seven treatments was evaluated on the basis of reduction in BSFB infestation on shoots and fruits of eggplant The individual control measure under each treatment as well as standard practice and untreated control are described and discussed below

## Details of the treatments

$T_1$= Mechanical control (comprising removal and destruction of infested shoots and fruits) + Cultural control (clean cultivation to keep the plot free from weeds, dry leaves and debris to discourage pupation);

$T_2$ = Mechanical and Cultural control + Sumi-alpha 5EC@ I ml/1 of water at 7days interval

$T_3$ = Furadan 5G @ 1 5 kg a i/ha single application at vegetative stage + Sumi-alpha

5EC @ 1 ml/1 of water at 7 days interval

$T_4$ = Suntap 50 WP @ 2g/l of water at 7 days interval

$T_5$ = Mechanical & Cultural control + Suntap 50WP @ 2 g/1 of water at 7 days interv al

$T_6$ = Mechanical & Cultural control + Suntap 50 WP @ 1 g/1 & Sumi-alpha 5EC @

$_1$ ml/1 of water at 5% infestation level

$T_7$= Untreated control

## Insecticides application

Sumi-alpha 5EC,Furadan 5G, and Suntap 50WP were collected from the local market of Gazipur District

Sumi-alpha 5EC was applied by mixing of insecticide @ 1 ml per litre of water The mixture in the spray machine was shaken well and sprayed covering the whole plants Seven litres spray material was required to spray three plots

Furadan 5G single dose was applied @ 1 5 kg a i./ ha by mixing the insecticide with soil and light irrigation afterwards during early vegetative stage

Suntap 50WP was applied by mixing 2g of insecticides with one litre of water and sprayed in the similar manner as sumialpha

All the time the insecticide mixture in the spray machine was shaken well and spayed by a Knapsack sprayer Before spraying, volume was calibrated to find out the required quantity of spray materials for three plots The required quantity was measured as 6 litres The spraying was done in the afternoon to avoid bright sunlight and drift caused by strong wind and to avoid adverse effect on beneficial insects

## Data collection

The comparative effectiveness of the 1PM packages in reduction of shoot and fruit borer infestation was evaluated on the basis of some pre-selected parameters The following parameters were considered during data collection

**Number of infested shoots:** The total number of shoots and the number of shoots infested by the BSFB was recorded at weekly intervals from each plot for each treatment during the period from January to July, 2005 and the weekly percent shoot infestation and its reduction over control were calculated for all the treatments In mechanical control the infested shoots were clipped, removed and destroyed after counting

$$\%\text{Shoot infestation} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

**Number of fruits per plot:** Data were collected on the basis of the number of harvested fruits per plot in each treatment The marketable fruits were harvested at 15 days intervals at some early, mid and late fruiting stages

**Number of healthy and infested fruits** Data were recorded on the basis of the number of the healthy fruits (HF) and infested fruits (IF) harvested at early, mid and late fruiting stages of the plant There was 2, 3 and 2 harvest at early mid and late fruiting stages, respectively. In total seven harvests were done throughout the fruiting period (April to June 2005) Infestation rate (by number and weight ) of brinjal fruits caused by BSFB at early, mid and late fruiting stages in different treatments and its reduction over control were calculated

**Weight of healthy and infested fruit** The weight of healthy and infested fruits at early ,mid and late fruiting stages of eggplants were taken separately per plot for each treatment

**Fruit infestation percent** The infested fruits were calculated at all reproductive stages using the following procedure

$$\%\text{ Fruit infestation by number} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

Weight of infested fruit

% Fruit infestation by weight =--------------------------------------- X 100
Total weight of fruit

The percentage of fruit infestation was calculated on the basis of the infestation occurred at each fruiting stage of the crop

Accumulated infestation rate (both by number and weight ) derived from early, mid and late fruiting stages for different treatments and its reduction over control were also calculated

## Fruit bearing capabilities of brinjal under various treatments:

The total fruit number and fruit weight of each treatment for each replication were recoded at early, mid and late fruiting stages Fruit bearing capabilities of brinjal treated with various treatments at each fruiting stage was determined on the basis of number and weight of fruits at that stage as percentage of the total fruits produced in different treatments. The following procedures were adopted to determine such percentage

$$\text{\% Fruit bearing ability at any fruiting stage} = \frac{\text{Number of fruit bearing ability at any fruiting stage}}{\text{Total number of fruits in that treatment}} \times 100$$

**Intensity of attack** Intensity of attack by BSFB at early, mid and late fruiting stages of brinjal treated with different treatments was calculated by the number of bores per fruit This was done by selecting 7 fruits randomly from each replication in each treatment after each harvest

**Yield per plot** After harvesting the weight of both healthy and infested fruits per plot was recorded in each treatment Total yield for each treatemt was obtained by adding healthy and infested fruit yield of that treatment

**Yield per hectare** The healthy and total yield of brinjal per hectare for each treatment was calculated in tons from the cumulative fruit production in a plot Eff ect of different treatments on the increase and decrease of brinjal yield over control was also calculated

## Photographs preparation:

During the study period, sseveral photographs were taken pertaining to the nature of damage on shoots and fruits.

## Data analysis:

The data were analyzed statistically for important parameters like percent shoot and fruit infestation, healthy and infested yield, fruit bearing capabilities, intensity of attack, etc The analysis of variance (ANOVA) of different parameters was performed and the range test of the means was done by using Duncan's Multiple Range Test (DMRT) Before statistical analysis, the data transformation was done where appropriate using square root transformation procedure for the accuracy of results Data were analyzed by MSTAT-C software

Relationship between shoot & fruit infestation and yield, relationship between the number of bores per fruit and infested fruit yield were shown by simple linear regression analysis

# CHAPTER IV

# RESULTS AND DISCUSSION

The results of comparative effectiveness consisting of seven treatment combinations (packages) of various control measures in reducing the infestation of brinjal shoot and fruit borer (BSFB )was evaluated and their suitability as 1PM packages was assessed Influence of these management practices on yield , extent of damage were presented and discussed under the following sections Experimental plot of brinjal in SAU farm during kharif-2005 was shown in Fig 1

## Nature of damage of *Leucinodes orbonalis* Guenee

An infested shoot with larva feeding inside is presented in Plate 2A Besides, infested fruits together with larvae feeding inside are presented in Plate 2B Infestation was recorded from both shoots and fruits The infested shoots were dried up which might be due to disruption of the vascular system and translocation of food materials from the proximal part to the distal part of the shoot Alam and Sana (1962) also reported the similar damage symptoms

## Effect of different treatments on shoot infestation of brinjal.

The comparative effectiveness of various control measures along with schedule spray on percent shoot infestation by the BSFB has been evaluated in terms of their efficacy in reducing shoot infestation over control were presented in Table 1

Plate 1. Experimental plot of brinjal in SAU farm during khant 2005.

**Plate 2. Infested shoot (A) of brinjal due to brinjal shoot and fruit borer (BSFB) attack and infested fruit (B), BSFB feeding inside the fruit.**

The results revealed that the lowest shoot infestation ( 6 0% ) was obtained from T<, consisting of Mechanical and cultural control + Suntap50WP@ 1 g/1 & Sumi-alpha5EC @ lml/1 of water , which differed significantly from all other treatments The second lowest shoot infestation ( 8 0% )was obtained from T? comprising mechanical and cultural control + Suntap50WP @ 2g/l of water at 7 days interval At followed by $T_4$ (9 0%), Ti(10 0%) Statistically there were significant differences among these four treatments The highest shoot infestation (17 0%) was recorded from untreated control, which was statistically different from all other treatments The second highest shoot infestation ( 14 0% )was observed from T| utilizing mechanical ^cultural control followed by $T_2$(12 0%) comprising mechanical and cultural control + Sumi-alpha5EC @ lml/1 of water Statistically there were significant differences among these three treatments.

The percent shoot infestation reduction over control was highest ( 64 71% ) in $T_{f>}$ followed by Ts (52 94%),and $T_4$(47 05%) For other treatments, this reduction was 47 06% for $T_3$, 29 41% for $T_2$ and 17 65% for T,

The comparisons of the results of the present study with the existing findings suggested that although significant reduction in shoot infestation was achieved over control, none of the treatments was able to exceed the efficacy reported by others who obtained about 80% reduction in shoot infestation over control However, Kabir *el al.* (1994) obtained similar results where chemical insecticide was not solely effective against the BSFB Yein (1985) and Parkash( 1988) reported that many insecticides failed to suppress this borer pest below Economic Injury Level(ElL) The overall level of BSFB infested shoot is higher in the study plot because of the higher temperature and relative

Table I Infestation of brinjal shoots caused by the brinjal shoot and fruit borer (BSFB) in different treatments and its reduction over control during Kharif 2005

| Treatment | *Mean shoot infestation (%) | Reduction of shoot infestation over control (%) |
|---|---|---|
| T1 | 14 00 b *(3.73)*** | 17 65 |
| $T_2$ | 12 00c (3 46) | 29 41 |
| $T_3$ | 10 00 d .... <120) | 47.06 |
| $T_4$ | 9 00 de (3.00) | 47.05 |
| $T_5$ | 8 00 e (2 80) | 52 94 |
| $T_6$ | 6.00 f (2 i | 64 71 |
| $T_7$ | 17 00 a (4.10) | |

T1=Mechanical control + Cultural control
$T_2$= Mechanical and Cultural control + Sumi-alpha 5EC@ lml/1 of water at 7 days interval
$T_3$~ Furadan 5G @ 1 5 kg a i /ha single application at vegetative stage+ Sumi- alpha 5EC@ 1 ml/1 of water at 7 days interval
$T_4$— Suntap 50 WP @ 2 g/1 of water at 7 days interval
Ts Mechanical and Cultural control + Suntap 50 WP @ 2g/l of water at 7 days interval
$T_6$- Mechanical and cultural control + Suntap 50WP @lg/l+ Sumi-alpha 5EC @ lml/1 of water at 5% infestation level
$T_7$ — Untreated control
*Mean of 3 replications ; each replication is derived from the mean of 10 observations
In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance
**Figures in parentheses are transformed (square root) values

humidity at vegetative stage during the months of March to July (Appendix I) The highest level of shoot infestation causes lowest yieid The heavy shoot damage at vegetative stage might play negative role in the subsequent tlower and fruit poduction of brinjal.

Rajavel *et al.* (1989) observed that synthetic pyrethriods (Clocythrin, cypermethrin. deltamethrin and ARC SPO 3) significantly reduced shoot infestation with Clocythrin at 31.5-50.00 ppm and deltamethrin at 20 ppm provided complete control Shoot infestation also reduced by the application of endrin, phosphamidon, cabofuran, monocrotophos,etc (Mehto and Lall, 1981 and Mirsa, 1993) Karim (1994) noted that cultural methods like hand picking and pruning, destroying crop residues are popular and useful for the management of brinjal shoot and fruit borer Verma( 1986) also reported that hand picking of infested shoots and fruits could be used as component of 1PM Ganguli *et a!\\91\)* obtained fruit yield of 1161 kg /ha for no treatment and 7495 kg/ha when infested shoots were removed by hand

Mechanical or cultural method may be supplemented with insecticidal application in increasing the percent shoot infestation reduction over the untreated control Thus the decreased rate of shoot infestation might be ensured by utilizing Treatment no 5 (T5) consisting of mechanical +cultural control + Suntap 50WP @ 2g/l Treatment 2(T2) consisting of mechanical ^cultural control + Sumi-alpha5EC@ 1 ml/1 might be chosen as the next line of defence

## Effect of different treatments on fruit infestation of brin jal.

The effet of various treatments on the percent fruit infestation at early, mid and late fruiting stages of the brinjal by number & weight and its infestation over control are presented in Tables 2-4

At early fruiting stage the mean percentages of fruit infestation (by number) among the treatments varied significantly (Table 2) The untreated control plots had the highest fruit infestation (72 22%), which differed most significantly with all treatments The second highest fruit infestation was 61.11% for T| which was followed by

where Mechanical and cultural control +Suntap 50 WP@ 1 g/1 + Sumi-alpha 5KC @lml/1 of water was used (36 11%) The second lowest fruit infestation was obtained from the

statistically identical but numerically different from others

The highest fruit infestation reduction over control (bv number) was recorded

2(35 39%), treatment 5( 35 38%), treatment 4( 30 76%), treatment 1 (15 38%) Ara *et al.* (1995) obtained 26 67%. Rahman *et al.(*\996) observed 24 33% and Khorsheduzzaman *et*

brinjal, where brinjal was planted in Rabi season Alam *et al.(2002)* also obtained 64 23% fruit infestation in control olot at earlv fruitine stage in brinial. where brinial was

Table 2. Infestation of brinjal fruits by BSFB at early fruiting stage in different treatments and its reduction over control during kharif 2005.

| Treatment | *Mean fruit infestation (%) | | Reduction of fruit infestation over control (%) | |
|---|---|---|---|---|
| | By weight | By number | By weight | By number |
| T, | 38 38 b (6 20)** | 6111b (7 80) | 30 31 | 15.38 |
| $T_2$ | 28 13 e (5.23) | 46 66 d (6 80) | 54 37 | 35 39 |
| $T_3$ | 25 13 f (5 00) | 44 44 e (667) | 37.25 | 38 46 |
| $T_4$ | 34 56 c (5 90) | 50 00 c (7.07) | 37.25 | 30 76 |
| $T_5$ | 30 98 d (5.57) | 46 67 d (6 83) | 43.75 | 35.38 |
| $T_6$ | 22 04 g (4 70) | 36 1 1 f (603) | 59.98 | 50.00 |
| $T_7$ | 55.08 a (7.43) | 72.22 a (8 50) | | |

T1=Mechanical control+ Cultural control

$T_2$= Mechanical and Cultural control + Sumi-alpha5EC @ lml/1 of water at 7 days interval

T3= Furadan 5G @ 1.5 kg a i/ha single application at vegetative stage + Sumi- alpha5EC @ 1 ml/1 of water at 7 days interval

$T_4$= Suntap 50 WP @ 2 g/1 of water at 7 days interval

$T_5$ Mechanical and Cultural control + Suntap 50 WP @ 2g/l of water at 7 days interval

$T_6$=Mechanical and cultural control* Suntap 50WP@ 1 g/1 + Sumi-alpha5EC @1 ml/1 of water at 5% infestation level

$T_7$= Untreated control

*Mean of 3 replications,each replication is derived from the mean of 2 observations

In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance

**Figures in parentheses are transformed (square root) values

At mid fruiting stage, the percentages of fruit infestation by number and weight varied significantly among treatments (Table 3) Plots having treatment $_6$ gave the lowest fruit infestation by number (35.55%) and weight (22 04%) The second lowest fruit infestation by number (39 28%) and by weight (23 96%) was observed in plots with Tj which was followed by 41 67%(by number) and 3 1 43% (by weight) in $T_2$ Similar to early stage, the highest fruit infestation both by number (76 67%) and by weight (67 70%) was obtained from untreated control followed by 55 57% and 55 00% by number, and 49 83% and 41 37% by weight in Ti and $T_4$, respectively having no significant difference among them

The highest reduction in fruit infestation by number (53 62%) was obtained from $T_6$ followed by T*(48 76%), $T_2$(45 63%), Ts( 34 78%) $T_4$(28 26%) and T,(27 51%) Similarly the highest fruit infestation reduction by weight was obtained in $T_6$ (68 38%) followed by $T_3$(65 62%), $T_2$(54 90%), $T_5$(40 65%), $T_4$(37 03%) and T,(28 51%)(Table 3)

Table 3. Infestation of brinjal fruits by BSFB at inid fruiting stage in different treatments and its reduction over controlduring khaif 2005.

| T reatment | •Mean fruit infestation (%) | | Reduction of fruit infestation over control (%) | |
|---|---|---|---|---|
| | Bv weight | By number | By weight | By number |
| **T1** | 49 83 b | 55.57 b | 28 51 | 27 51 |
| | (7.03)** | (747) | | |
| $T_2$ | 31 43 e | 41 67 d | 54.90 | 45 63 |
| | (5.60) | (7 47) | | |
| $T_3$ | 23 .96 f | 39.28 e | 65.62 | 48 76 |
| | (4 90) | (607) | | |
| $T_4$ | 43 89 c | 55.00 b | 37.03 | 28 26 |
| | (6 60) | (7 47) | | |
| $T_5$ | 41.37 d | 50.00 c | 40.65 | 34 78 |
| | (6 43) | r r, | | |
| $T_6$ | 22.04 g | 35.55 f | 68 38 | 53.62 |
| | (6 70) | (5.800 | | |
| $T_7$ | 69 707 a | 76 67 a | | |
| | (8 33) | (8.77) | | |

T1=MechanicaI control^ Cultural control
T 2~ Mechanical and Cultural control + Sumi-alpha5EC @ lml/1 of water at 7 days interval
$T_3$= Furadan 5G @15 kg a i /ha single application at vegetative stage + Sumi alpha 5EC @ 1 ml/1 of water at 7 days interval
$T_4$= Suntap 50 WP @ 2 g/1 of water at 7 days interval
T5= Mechanical and Cultural control + Suntap 50 WP@ 2g/l of water at 7 days interval
$T_6$=Mechanical and cultural control+ Suntap 50WP@ 1 g/1 + Sumi-alpha5EC @ lml/1 of water at 5% infestation level
$T_7$ — Untreated control
*Mean of 3 replications each replication is derived from the mean of 3 observations
In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance
**Figures in parentheses are transformed (square root) values

At late fruiting stage (Table 4), significantly highest fruit infestation by number was observed in untreated control plot (76 66%), which was statistically varied with others The lowest fruit infestation was recorded in T<, (33 33%) followed by plots of T* (36 66%) Other treatments gave the intermediate level of infestation In case of weight, the highest fruit infestation was observed in untreated control plot (64 64%), which was statistically varied with others The lowest fruit infestation was recorded in Tf, (30 48%) followed by plots of Tj (30 85%) In Tr, and Tv respectively having no significant difference among them

Like shoot infestation, early and mid fruiting stages, the highest fruit infestation reduction over control by number was recorded in $T_{()}$ (56.52%) at late fruiting stage The plots with T} also accounted 52 18% fruit infestation reduction which was followed by $T_2$ ( 27 53%), $T_5$ ( 27.53%), $T_4$( 27 54%),and Ti( 27 53% ) when the percent infestation by number was considered When the percent fruit infestation reduction by weight was considered, the descending order of percent fruit infestation reduction over control was $T_6$< T* < $T_2$< $T_5$< $T_4$< Ti Percent results revealed the lower infestation in late fruiting stage than early and mid fruiting stages. Alam *et al (*2002) observed lower fruit infestation in late fruiting stage than early and mid fruiting stages during Kharif season

1 able 4. Infestation of brinjal fruits by BSFB at late fruiting stage in different treatments and its reduction over control during kharif 2005.

| Treatment | •Mean fruit infestation (%) | | Reduction of fruit infestation over control (%) | |
|---|---|---|---|---|
| | By weight | By | By weight | By number |
| $T_1$ | 51 07 b **(7 13) | 55.55 b (7 47) | 20 99 | 27.53 |
| $T_2$ | 40 92 e (6 40) | 55.55 b (747) | 36 68 | 27.53 |
| $T_3$ | 30.85 f (5.57) | 36 66 c (6.06) | 52.27 | 52.18 |
| $T_4$ | 47.03 c (6 87) | 55.55 b (747) | 27.24 | 27.54 |
| $T_5$ | 43.35 d (6 60) | 55.55 b (7 47) | 32 93 | 27.53 |
| $T_6$ | 30.48 f (5 50) | 33.33 d (5 80) | 52 84 | 56 52 |
| $T_7$ | 64 64 a (8.03) | 76.66 a (8.77) | | |

T1=Mechanical control* Cultural control
$T_2$= Mechanical and Cultural control + Sumi-alpha @ lml/1 of water at 7 days interval
T3= Furadan 5G @ 1 5 kg a i /ha single application at vegetative stage + Sumi- alpha 5 EC@ 1 ml/1 of water at 7 days interval
$T_4$= Suntap 50 WP @ 2 g/1 of water at 7 days interval
$T_5$ Mechanical and Cultural control + Suntap 50 WP@ 2 g/1 of water at 7 days interval
$T_6$=Mechanical and cultural control + Suntap 50WP @ lg/l+ Sumi-alpha 5EC @ 1 ml/1 of water at 5% infestation level
$T_7$ — Untreated control
*Mean of 3 replications,each replication is derived from the mean of observations.
In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance
**Figures in parentheses are transformed (square root) values

Data ot fruit intestation of all fruiting stages were pooled together and presented in 1 able 5 Mean percentages of fruit infestation among treatments both by number and weight varied significantly. As the results of individual fruiting stage, $T_6$ had the lowest intestation (38 67% by number and 25.75% by weight) and produced highest infestation reduction over control (75.52% by number and 63 72% by weight) The second lowest fruit infestation was recorded from T-» (411 1% by number and 25 96% by weight) The mean percentages of fruit infestation obtained from two treatments both by number and weight were statistically identical (Table 5) Similar to shoot infestation (Table 1), untreated control gave the highest fruit infestation while the rest of the treatments manifested 51 28-52.38% and 33.53-43 85% fruit infestation by number and weight, respectively When number was considered for estimating fruit infestation, T| had statistically identical fruit infestation with T2 but both were statistically different Ti and $T_2$ gave statistically different fruit infestation from each other when weight was considered

$T_6$ provided the highest reduction in fruit infestation (48 79% by number) followed by T,(45 56%), $T_2$( 32 24%), $T_4$(32 10%), $T_5$(32 09%) and T,(30 64%) by number Similar trend was obtained when infestation level by weight was considered

The results thus obtained in the present study when compared to the findings reported by other workers suggest that all the treatments including the T«, which achieved the highest reduction of 48 79% by number and 59.58% by weight were less effective in reducing the fruit infestation as compared to those reported by them In an experiment conducted at BARI, Gazipur during Rabi, 1994-95, Decis was found to show the highest level of efficacy and rendered 63 31% reduction of fruit infestation over control Arrivo

I able 5. Infestation of brinjal fruits (early, mid and late fruiting stages) by BSFB in different treatments and its reduction over control during kharif 2005.

| Treatment | *Mean fruit infestation (%) | | Reduction of fruit infestation over control (%) | |
|---|---|---|---|---|
| | By weight | By number | By weight | By number |
| T1 | 43 85ab **(6 60) | 52 38 b (7.23) | 3118 | 30 64 |
| $T_2$ | 33.53 b (4 50) | 5117 b (7.17) | 47.37 | 32.24 |
| $T_3$ | 25 96 b (5 10) | 4111 c (6 40) | 59 26 | 45.56 |
| $T_4$ | 41 01a b (643) | 51 28 b (7.17) | 35 64 | 32 10 |
| $T_5$ | 37 45ab (6 10) | 51 28 b . - r. | 41 23 | 32 09 |
| $T_6$ | 25.75 b (5 10) | 38 67 d (620) | 59 58 | 48 79 |
| $T_7$ | 63.72 a (797) | 75.52 a (8 67) | | |

T1=Mechanical control^ Cultural control
$T_2$ = Mechanical and Cultural control + Sumi-alpha5EC @ lml/1 of water at 7 days interval
T?= Furadan 5G @ 1 5 kg a i /ha single application at vegetative stage + Sumi-alpha 5EC@ 1 ml/ I of water at 7days interval
$T_4$= Suntap 50 WP @ 2 g/1 of water at 7 days interval
T5 Mechanical and Cultural control + Suntap 50 WP@2g/l of water at 7 days interval
$T_6$=Mechanical and cultural control + Suntap 50WP @ 1 g/1 + Sumi-alpha 5EC @ lml/1 of water at 5% infestation level
$T_7$ = Untreated control
*Mean of 3 replications each replication is derived from the mean of 7 observations
In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance
**Figures in parentheses are transformed (square root) values

and Bestox achieved 56 94% and 51 33% reduction in fruit infestation, respectively over control (Anon, 1995) However, Kabir et al (1994) reported results similar to the present study and apprehended development of resistance as a cause of poor performance of insecticides in reducing the BSFB infestation Yein (1985) ,Parkash (1988), and Banerjee and Basu(1952) also reported that insecticides were not able to suppress this borer pest below the Economic Injury Level (ElL)

Rahman *el al.* (1996) accounted only 6 17 and 1.51% fruit infestation (by weight) in mechanical + grafted eggplant and Cymbush + grafted eggplant , respectively Khorsheduzzaman et al (1998) achieved significant reduction in fruit infestation when chemical and non-chemical approaches were integrated for the management of BSFB

It is thus revealed from Table 1 and 5 that the rate of infestation is higher on fruits than the shoots, which are in agreement with the findings reported by Butani, and Jotwani (1984) who also observed that the borers preferred the fruit to shoots during the fruiting stage Alam and Sana(1962) also reported higher rate of infestation in fruit than in shoots during the fruiting period

Considering shoot and fruit infestation, $T_6$ and T^ provided better results than other treatments Present results clearly revealed that chemical measures incorporated with non-chemical tools (i.e. cultural or mechanical method) might provide better performance to reduce the fruit infestation in brinjal

## Effect of different treatments on the yield of brinjal

Healthy fruit yield, infested fruit yield and total yield obtained from different treatments varied significantly (Table 6) The treatment 6 produced the highest healthy truit yield (15 84 t/ha) followed by T-»(14 10 t/ha) and $T_2$ (9 33 t/ha) It was evident that there were signiticant differences among themselves Conversely, the lowest healthy fruit yield was recorded from plots received untreated control (3 22 t/ha) $T_4$ & $T_5$ gave intermediate level of healthy fruit weight, which was not statistically different from others(Table 6)

In case of infested fruit yield, the highest yield was obtained from plots having $T_6$( 5 12 t/ha) followed by $T_3$ (5 08 t/ha) ,$T_2$(4 89 t/ha), $T_4$(4 86 t/ha) and Ts(4 86 t/ha) and there were no significant difference among these treatments On the contrary, the lowest infested fruit yield was obtained from $T_7$ ( 2.77 t/ha) followed by $T_t$ (3 56 t/ha) and there were significant difference among them

The total fruit yield was maximum (20.96 t/ha) in plots having $T_6$ followed by plot treated with $T_3$(19.18 t/ha) and $T_2$(14 16 t/ha) The lowest total fruit yield was obtained from plot with untreated control (5 99 t/ha) followed by Ti(8 02 t/ha)and $T_4$(12 48 t/ha) The above results indicated that $T_6$ gave the highest healthy and total yield The lower yield in $T_1$ was might be due to inability of the non-chemical approaches to provide appreciable reduction in fruit infestation in absence of chemical in the treatment But, cultural or mechanical control may cause an additive effect to chemical measures, which were already evident in $T_6$ and $T_3$

**I able 6. Y ield of brin jal from different treatments during kharif 2005.**

| Treatment | * Mean yield (t/ha) | | |
|---|---|---|---|
| | Healthy | Infested | Total |
| T, | 4 46 e<br>**(2 10) | 3 .56 b<br>(1 87) | 8 02 d<br>(2.80) |
| $T_2$ | 9.33 c<br>(3 07) | 4 89 a<br>(2 20) | 14 16 b<br>(3 77) |
| $T_3$ | 14 10 b<br>(3 80) | 5 08 a<br>(2.27) | 19 18 a<br>(4 47) |
| $T_4$ | 7 62 d<br>(2.77) | 4 86 a<br>(2 20) | 12 48 c<br>(3 53) |
| $T_5$ | 8 16 d<br>(2.87) | 4 86 a<br>(2 20) | 13 02 c<br>(3 60) |
| $T_6$ | 15 84 a<br>(3.97) | 5.12 a<br>(2.27) | 20 96 a<br>(4 60) |
| $T_7$ | 3 .22 f<br>(1 80) | 2.7 7c<br>(1 63) | 5 99 e<br>(2.37) |

T1=Mechanical control + Cultural control
$T_2$~ Mechanical and Cultural control + Sumi-alpha 5EC@ lml/1 of water at 7 days interval
T3= Furadan 5G @ 1 5 kg a i /ha single application at vegetative stage+ Sumi-alpha 5EC@ 1 ml/1 of water at 7 days interval
$T_4$= Suntap 50 WP @ 2g/l of water at 7 days interval
$T_5$ Mechanical and Cultural control + Suntap 50 WP @2 g/1 of water at 7 days interval
$T_6$-Mechanical and cultural control + Suntap 50WP @lg/l+ Sumi-alpha5EC @ 1 ml/1 of water at 5% infestation level
$T_7$ — Untreated control
*Mean of 3 replications , each replication is derived from the mean of 7 observations
In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance
**Figures in parentheses are transformed (square root) values.

The results of yield increase/ decrease in different treatments over untreated control are summarized in I able 7 The highest percentage of yield (healthy fruits) increase over control was obtained from the plot where $T_r$, was administered (391 68%) The 2'Kt and 3r,' highest increase were recorded from plot having $T_3$ ( 337 48%) and plots treated with 12 ((189 69%) While the lowest increase over control was obtained from plots with Ti(38 38%) followed by $T_4$ (136 42%) and Ts (153.18%) In this case the total fruit yield, yield increase followed the similar trend as observed for the heaithy fruits

Although direct comparison of the present findings could not be done with the findings of elsewhere due to lack of reference of similar nature, however, Khaire *et al.* (1986) reported that the best control of BSFB and the highest yield of marketable fruits (91 1 q/ha) were ensured by 0 015% cypermethrin applied at flowering and repeated 4 times at 10 days interval Similarly 3 to 4 spray of cypermethrin 10EC or cvfluthrin (Bethroid) 50EC @ lml/1 of water or fenvalerate 20EC @05 ml/1 of water at an interval of 15 days starting from the first flowering was found effective in controlling the BSFB in Bangladesh (Anon. 1991)

Agnihotri *et al.* (1990) in an evaluation found cypermethrin (0 00125%) as the most effective against the infestation of BSFB on two cultivars of brinjal Pusa Parple Long in India Nath and Chakraborty (1980) like wise reported that carbofuran at 6 kg a i /ha effectively reduced the incidence of BSFB at all stages of crop growth , and also gave a yield increase of about 73% Pawar *et a!* ( 1986) reported that carbofuran applied at 50 kg a i./ha 10 days after transplanting, followed by either 3 sprays with 0 006% cypermethrin at 14 days intervals starting 52 days after transplanting or 5 sprays with cypermethrin at 14 days intervals starting 10 days after transplanting provided economic control of BSFB Rajavel *el al.*, (1989) reported that out of 4 synthetic pyrethroids (Clocythrin, cypermethrin, deltamethrin and ARC SPO 3), 65 6 ppm Clocythrin resulted in the lowest fruit infestation All pyrethroids significantly increased healthy fruit yield with 25 ppm Clocythrin producing the best yield (15.97 t/ha)

Khorsheduzzaman *el al.* (1998) documented that brinjal yield were 30 23 t/ha and 23 18 t/ha when plants were treated with Cymbush at 7 days interval and Cumbush applied at 5% AT Rahman *el al* (1996) also found that Cymbush on grafted eggplants gave highest yield( 49 36 t/ha) They also opined that mechanically grafted eggplant produced 37 06 t/ha yield

**I able 7. Kffect ol different treatments on the increase or decrease of brinjal yield over control during Kharif 2005.**

| Treatment | *Mean healthy fruit yield (t/ha) | Yield increase/decrease over control (%) | *Mean total fruit yield (t/ha) | Yield increase/decrease over control (%) |
|---|---|---|---|---|
| T, | 4 46 e **(2 10) | 38.38 | 8 02 d **(2 80) | 33 88 |
| $T_2$ | 9 33 c (3.07) | 189 48 | 14 16 b (3.77) | 136 39 |
| $T_3$ | 14.10b (3.80) | 337 48 | 19 18 a (447) | 220 20 |
| $T_4$ | 7.62 d (2.77) | 136 42 | 12 48 c (3.53) | 108 34 |
| $T_s$ | 8 16 d (2.87) | 153 18 | 13 02 c (3 60) | 117 36 |
| T1 | 15 84 a <^r> | 391 68 | 20.96 a (4 60) | 249.91 |
| $T_7$ | 3.22 f (1 80) | | 5 .99 e (2.37) | |

T1=Mechanical control + Cultural control
$T_2$= Mechanical and Cultural control + Sumi-alpha5EC@ lml/1 of water at 7 days interval
T3= Furadan 5G @ 1 5 kg a i /ha single application at vegetative stage + Sumi-alpha5EC @ 1 ml/1 of water at 7 days interval
$T_4$= Suntap 50 WP @ 2 g/1 of water at 7 days interval
Ts Mechanical and Cultural control + Suntap 50 WP@2 g/1 of water at 7 days interval
T6=Mechanical and cultural control + Suntap 50WP @ 1 g/l+ Sumi-alpha5EC@ 1ml/l of water at 5% infestation level
2$T_7$ — Untreated control

*Mean of 3 replications;each replication is derived from the mean of 7 observations
In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance
** Figures in parentheses are transformed (square root) values.

## Fruit bearing capabilities of brinjal under various treatments

The total yield of eggplant is divided into early, mid and late fruiting stages and percentage of fruit production both in number and weight has been shown in Table 8

At early lruiting stage significantly the highest fruit number was produced in plants of Tf, (1 1 00) comprising Mechanical and cultural control +Suntap 50WP(3)lg/l + Sumi-alpha5EC @lml/1 of water This was statistically similar to Tv Significantly the lower fruit number was produced in untreated control plots (2 433) Higher percent of total fruit in terms of number (3 30%) and weight (26 80%) was also produced in plants of treatment 6, while the lowest was in cultural + mechanically controlled brinjal plots under treatment 1 (Ti) Percentage in terms of number is lower than those of weight in all the treatments at early,mid and late fruiting stages

At mid fruiting stage, most of the fruits were produced in all the treated plots. The percentage in terms of number and weight varied little among them Statistically similar but higher fruit in terms of number and weight was produced in plant under treatment 6 ($T_6$), Ti and $T_2$ and these were significantly different from those produced in plots under T,,$T_4$ and Ts (Table 8)

At late fruiting stage significantly higher number of fruits were produced in plants of $T_6$ and this was statistically different from the rest of treatments Statistically similar number of fruits was harvested in the plots under $T_4$ and $T_5$ but significantly different from these of untreated plots Faiits in terms of weight at this stage were followed similar fashion as in numbers Significantly the highest fruit weight was obtained in Mechanical and cultural control +Suntap50WP @ 1 g/1 & Sumi-alpha5EC @ lml/1 of water under T,, and the lowest in untreated control plots The percentage in terms of number varied from

3 20 to 3 00% and in terms of weight from 14 27 to 27 43% The variation in weight was due to variable i e individual fruit weight, number, etc at this stage Similar results in fruit number and weight was obtained by Rahman *et al (*1996) when cultivated brinjal ‘Singnath' shoot grafted on *Solatium torvum* with various control measures

**1 able 8. Fruit bearing capabilities of brinjal treated with various treatments at early, mid and late fruiting stages during kharif 2005.**

| Treatment | Early fruiting stage | | Mid fruiting stage | | Late fruiting stage | |
|---|---|---|---|---|---|---|
| | **Weight (S)** | **Nu mber** | **Weight (g)** | **Number** | **Weight (g)** | **Number** |
| T, | 425 60 f **(20 63) | 6 67 c (268) | 536 00 b (23.20) | 11 67 c (3 43) | 254 50 e (15 97) | 5 66 cd (240) |
| $T_2$ | 593 30 c (24.37) | 10 00 ab (3.17) | 1269 00 ab (35 60) | 17.67 b (420) | 540 90 c (23.27) | 7 66 ab (2.77) |
| $T_3$ | 615.50b (24 80) | 11 00 a (3 30) | 1499 00 ab (29 87) | 19 00 ab (4 37) | 693 20 b (26 30) | 8 66 ab (2.93) |
| $T_4$ | 520 30 e (22 80) | 8 33 b (2.90) | 630 60 ab (25 10) | 12 00c (3 47) | 277 10 d (16 63) | 6.66bc (2.60) |
| $T_5$ | 556 50 d 23 60 | 9 66 ab (3.10) | 790 40 ab (28 10) | 12 67 c (3.57) | 538 50 c (23.20) | 7 00 be (260) |
| $T_6$ | 719 10 a (26 80) | 11 00 a (3 30) | 1605.00 a (40 10) | 21 00 a (4 57) | 752.50 a (27 43) | 9 00 a (3 00) |
| $T_7$ | 283 lOg (16 83) | 6 00 c (2 43) | 470 20 b (21.70) | 11 00 c (3.30) | 203 .50 f (14 27) | 5 00 d (2 20) |

T1=Mechanical control + Cultural control

$T_2$- Mechanical and Cultural control + Sumi-alpha 5EC@ lml/1 of water at 7 days interval

$T_3$= Furadan 5G @ 1 5 kg a i /ha single application at vegetative stage + Sumi-alpha 5EC@ 1 ml/1 of water at 7 days interval

$T_4$= Suntap 50 WP @ 2g/l of water at 7 days interval

$T_5$ Mechanical and Cultural control + Suntap 50 WP @ 2g/l of water at 7 days interval

$T_6$=Mechanical and cultural control + Suntap 50WP@lg/l + Sumi-alpha 5EC @lml/l at 5% infestation level

$T_7$— Untreated control

'"Values are averages of 3 replications

In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance

**Figures in parentheses are transformed (square root) values

**Intensity of attack by brinjal and fruit borer (BSFB) at different reproductive stages of brinjal treated with various control measures.**

The fruiting time of brinjal is divided into early, mid and late stages The intensity ot attack by BSFB at these reproductive stages has been shown in Table 9 At early fruiting stage intensity of attack was lowest in treatment $_6$ followed by T* and $T_2$ There was no significant difference in the intensity of attack among the treatments On the contrary, the highest intensity of attack was observed in the fruits of untreated control plots followed by T|, $T_4$ and Ts The extent of intensity of attack was numerically lower compared to those of mid and late fruiting stages of brinjal of all the treatments and untreated control plots This was probably because of the fact that the number of fruits at this stage was higher compared BSFB females in the plots At mid fruiting stage intensity of attack was lowest in treatment $_6$ followed by $T_3$, $T_2$, $T_4$ and Ts There was no significant difference in the intensity of attack among the treatments ( $T_2$, $T_3$, $T_4$, $T_5$) On the contrary,the highest intensity of attack was observed in the fruits of untreated control plots followed by T1

At late fruiting stage significantly the highest intensity of attack by this pest was found on untreated control plots and lowest in Mechanical & cultural control + Suntap 50WP @lg/l & Sumi-alpha 5EC@lml/1 of water under treatment $_6$($T_6$) Similarly, no significant difference in their intensity of attack was found at late fruiting stage of various treatments under various control measures

From this table it was evident that the higher intensity was generally found at late fruiting stages of almost all treatments including control compared to early and mid stages The higher intensity in this stage might be due to the host preference behaviour of BSFB, which prefers fruits rather than shoots at this stage when the number of fruits are lower compared to number of adult females This situation compelled female to deposit more eggs per fruit

Therefore, to reduce the infestation of attack by BSFB at all reproductive stages of eggplant ,the application of treatment 6 and treatment 3 may be suggested

**1 able 9. Intensity of attack by BSFB at early, inid and late fruiting stages of brinjal treated with different treatments during Kharif 2005.**

| Treatment | *Bore per fruit at early fruiting stage | *Bore per fruit at mid fruiting stage | *Bore per fruit at late fruiting stage |
|---|---|---|---|
| T, | 2 00 a<br>**(1 40) | 2 40 a<br>(1 53) | 2 33 a<br>(1 47 |
| $T_2$ | 1 73ab<br>(1 2 7) | 1 76 ab<br>(1 30) | 1 66 a<br>(1.30) |
| $T_3$ | 1 73 ab<br>(1 ?<>, | 1 66 ab<br>(130) | 1 66 a<br>(130) |
| $T_4$ | 1 96 a<br>(1 40) | 2.00 ab<br>(1 40) | 1 96 a<br>(1 40) |
| $T_5$ | 1 96 a<br>( 1 4 0. | 1 96 ab<br>(1 40) | 1 86 a<br>0 40) |
| $T_6$ | 1.10b<br>< 1 ()3 _) | 1.43 b<br>(1 20 | 1 53 a<br>(1 20) |
| $T_7$ | 2.40 a<br>(150) | 2 43 a<br>(157 ) | 2 40 a<br>(150) |

T1~ Mechanical control + Cultural control
$T_2$= Mechanical and Cultural control + Sumi-alpha 5EC@ lml/1 of water at 7 days interval
$T_3$= Furadan 5G @ 1 5 kg a i./ha single application at vegetative stage + Sumi-alpha 5EC@ 1 ml/1 of water at 7 days interval
$T_4$= Suntap 50 WP @ 2g/l of water at 7 days interval
Ts Mechanical and Cultural control + Suntap 50 WP @2g/l of water at 7 days interval
T6=Mechanical and cultural control + Suntap 50W'P@1 g/1 + Sumi-alpha 5EC @ 1 ml/1 of water at 5% infestation level
$T_7$ = Untreated control * Values are averages of 3 replications
In column, values followed by same letter(s) are statistically identical by DMRT at 5% level of significance
**Figures in parentheses are transformed (square root) values

## Relationship between shoot infestation and yield

The shoot infestation of brinjal by BSFB and yield had a negative correlation, which indicated that shoot infestation did not have direct effect on yield A regression line was fitted between shoot infestation (%) and yield (Figure 1) The correlation coefficient (r) was - 0 82 and the contribution of $R^{:}$ = 0.6755 indicated that only 67 55% yield could be influenced by shoot infestation

## Relationship between fruit infestation (by number) and yield

The results revealed that there was a negative correlation between percent fruit infestation (by number) and total yield This indicated that increase of fruit infestation (by number) there was a progressive fall in total yield A regression line was fitted between fruit infestation (by number) and total yield shown in (Figure 2) The correlation coefficient (r) was -0.88 and the contribution of R'= 0 7713 indicated that 77 13% of total yield could be affected by the variation in fruit infestation (by number)

## Relationship between fruit infestation (by weight) and total yield

There was a negative correlation between percent fruit infestation (by weight) and total yield It indicated that higher the fruit infestation (by weight) conversely lower the total fruit yield A linear regression line was fitted between fruit infestation (by weight) and total yield (Figure 3) The correlation coefficient (r) was -0 68 and the contribution of $R^2$=0 4613 indicated that 46 13% variation of total yield could be caused by percent fruit infestation (by weight)

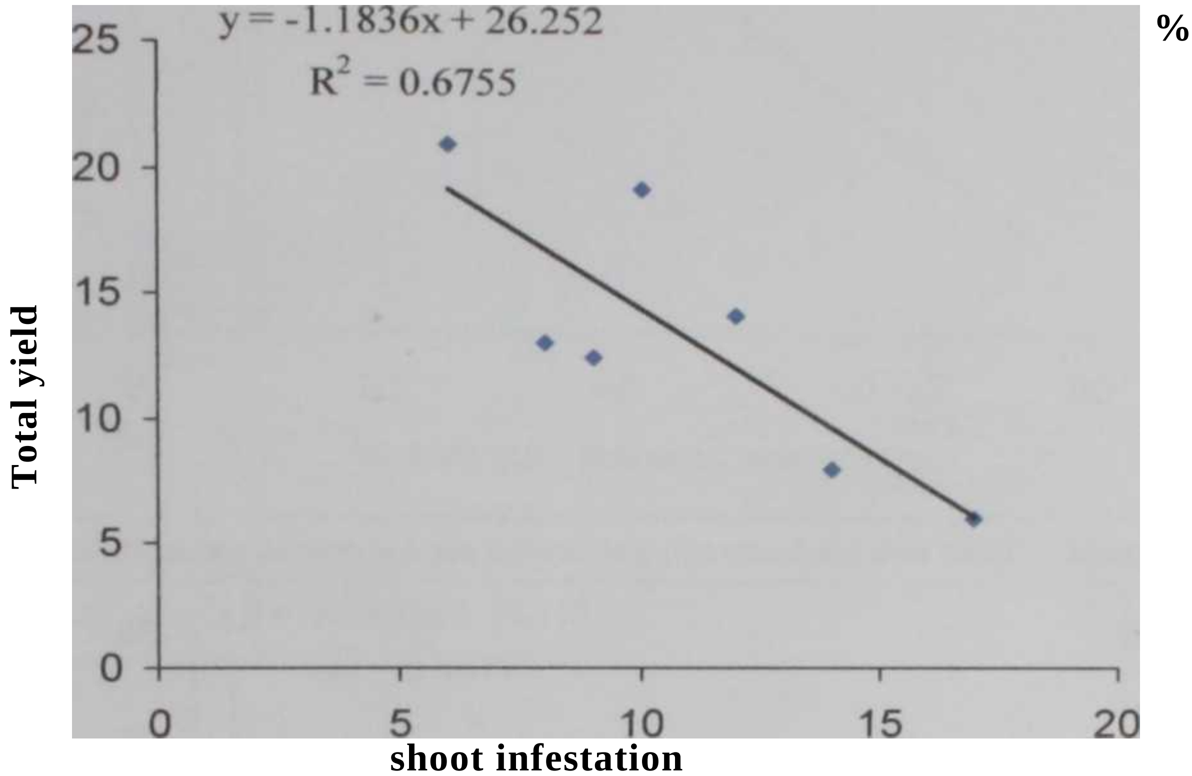


**Figure 1. Relationship between shoot infestation and yield of brinjal.**

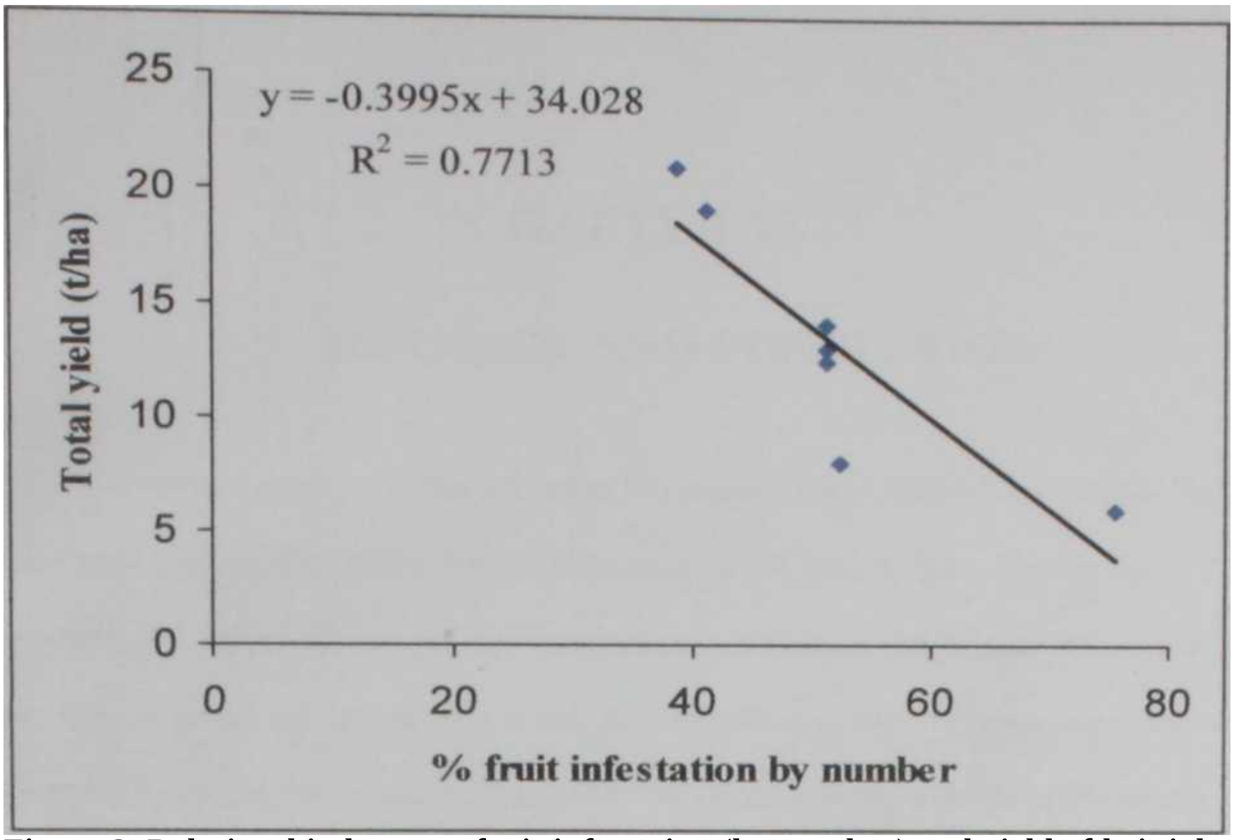


**Figure 2. Relationship between fruit infestation (by number) and yield of brinjal.**

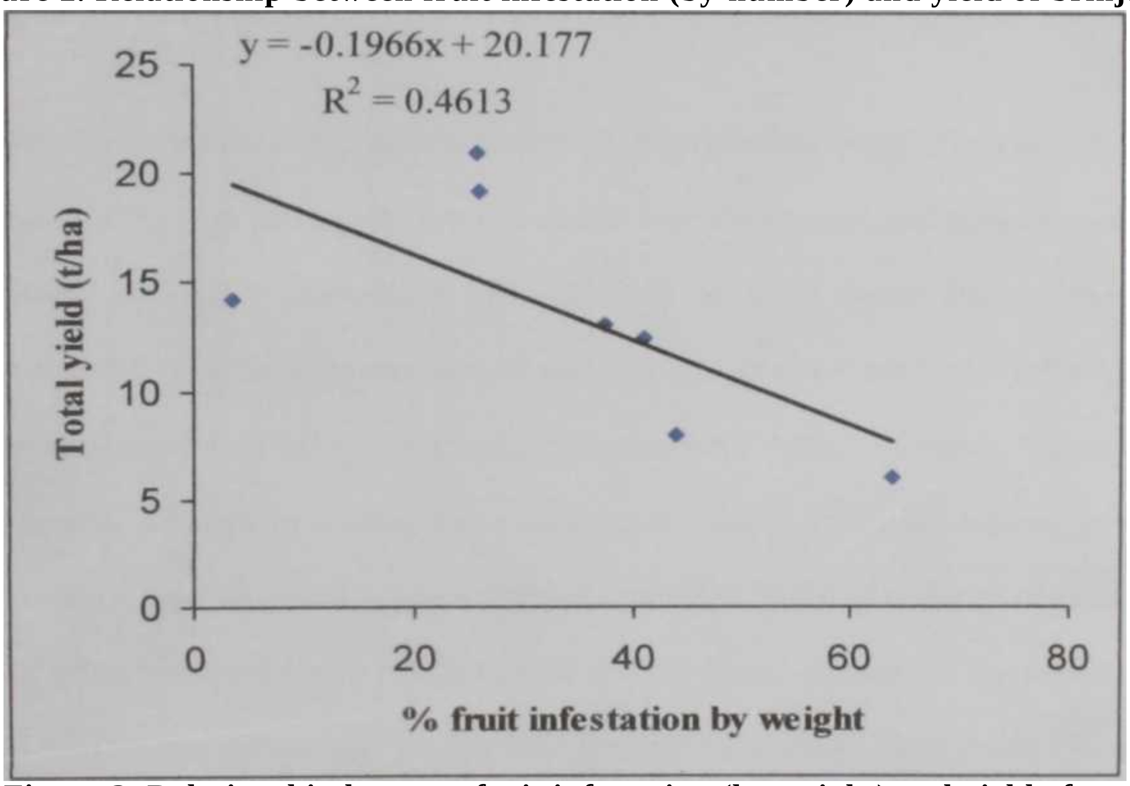


**Figure 3. Relationship between fruit infestation (by weight) and yield of brinjal.**

# CHAPTER V

# SUMMARY AND CONCLUSION

The current study was carried out at the experimental farm of the Sher-e- Bangla Agricultural University, Dhaka, Bangladesh, during the period from April to July, 2005 to evaluate the effect of various IPM packages to suppress the brinjal shoot and fruit borer over a cropping season To meet the objective, seven treatment combinations (packages) consisting of mechanical and cultural control along with suitable insecticides (Sumi-alpha 5EC, Suntap 50WP, Furadan 5G) at different doses and time intervals were tested

Out of seven treatments, significantly the lowest percent shoot infestation (6 00%) was obtained in the plots having treatment 6 containing Mechanical and cultural control + Suntap 50WP @ 1 g/1 & Sumi-alpha 5EC @ lml/1 of water which was followed by treatment 5 (8 00%) comprising mechanical and cultural control + suntap50WP@ 2g/l of water and treatment 4 (9 0%) consisting of Suntap50WP @2g/l of water There were sharp statistical differences among these treatments Significantly the highest percent shoot infestation was obtained in the untreated control (17 0%) All the treatments had significant effect compared with the untreated control plots The rest of the treatments( T,.$T_2$ and T,) showed statistically comparable level of infestation Thus, more than 50% reduction of shoot infestation over the control was obtained in plots having $T_6$ and $T_5$

At early fruiting stage all the treatments had significant effect in fruit infestation (by number and weight) compared to untreated control Significantly the highest fruit infestation (72.22%) by number and weight (55.08%) was obtained from untreated control, which was statistically different from others Significantly the lowest fruit intestation was obtained from the plots having treatment 6 by number (36 1 1%) and by weight (22 04%) and was followed by plots with treatment 3. Similar results were also evident at mid fruiting stage

At late fruiting stage, plots having treatment 6 had significantly lowest fruit infestation both by number (33.33%) and weight (30 48%) Significantly the highest fruit infestation was observed by number 76.66% and weight 64 64% from untreated control The rest of the treatments had the intermediate level of fruit infestation by number (36 66-55.55%) There was no significant difference among Ti, $T_2$,$T_4$ and $T_5$ in respect of number At mid fruiting stage, fruit infestation was higher compared to early and late fruiting stage. None of the treatments exceeded the standard level of 80% reduction of fruit infestation over control at any fruiting stage

The total fruit yield was maximum (20 96 t/ha) in plots of treatment 6, followed by treatment 3(19 18 t/ha),treatment 2 (14 16 t/ha) There was no significant difference between $T_6$ &$T_3$. Significantly lowest fruit yield was obtained from the control plots(5 99t/ha) followed by Ti,$T_4$&$T_5$ Healthy yield followed the same trend as in total yield Significantly higher healthy fruit yield was obtained from $T_6$ (15 84 t/ha) followed by T*(14 10 t/ha)and $T_2$(9 33 t/ha). Significantly the lowest healthy fruit yield was obtained in plots with untreated control (3 22 t/ha). The intermediate level of healthy fruit yield was harvested from the plots with $T_1$. $T_4$& Ts(4.46,7 62 &8 16 t/ha) but there was no siunificant differences between $T_4$ &T? The infested fruit yield was significantly lower in T?(2.77 t/ha) as against the maximum ( 5 12 t/ha) in treatment 6($T_6$)

Accordingly, treatment6 ($T_6$) ensured maximum increase ( 391 68%) of healthy fruit yield followed by T,(337 48%) and $T_2$(189 48%)

At early fruiting stage the highest percentage of total number of fruit and weight were found in plots of ^Maximum fruit both in number and weight were harvested in mid fruiting stages in all treatments including control At late fruiting stage percent fruit was greater than those of fruit weight in all the treatments and reverse was evident in early fruiting stage The intensity of attack by BSFB was numerically higher in all the treatments at mid and late fruiting stages Significantly the highest intensity was found in untreated control plots and the lowest in plots of Tc, at late fruiting stage and this was statistically identical with those of the rest of treatments.

Percent shoot and fruit infestation were negatively correlated with the total yield The number of bores per fruit was positively correlated with infested fruit yield

The present study revealed that the increased yield per hectare of eggplant with decreased rate of fruit /shoot infestation might be ensured by utilizing $T_6$ comprising application of Mechanical and cultural control + Suntap 50WP @ 1 g/1 & Sumi- alpha5EC @ lml/1 of water T» consisting of Furadan 5G @ 1.5 kg a i/ha single application + Sumi-alpha 5EC @ lml/1 of water might be chosen as the next line of defence These two treatments ($T_6$ & $T_3$) utilized judicious use of selective chemicals supplemented with non-chemical approaches for combating this obnoxious pest $T_2$ & $T_5$ also have significant effect in suppressing this pest and it might be tested with other chemical and non-chemical components (i.e pheromones, botanicals, etc.) to combat this pest However, further on-station and /or on-farm trials may be undertaken in order to confirm the validity of these results.

# CHAPTER VI

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# APPENDICES

Mean monthly weather data at experimental farm of Sher-e-Bangla Agricultural University (SAU),Dhaka ,Bangladesh during the period from January to July,2005

| Temp(°C) | Relative humidity(%) | Rainfall(mm) |
|---|---|---|
| Jan 18 8 | 58 | 3.5 |
| Feb 22.5 | 55 | 12 5 |
| Mar 27.6 | 58 | 36 |
| Apr 28.3 | 70 | 160.5 |
| May 30.7 | 63 | |
| | 79 | 406.5 |
| Jun 28.6 July 28.5 | 79 | 335.5 |



**Figures in parentheses are transformed (square root) values