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# Protective and Curative Measures Against Litchi Fruit Borer *(Conopomorpha sinensis)*

BARI G M M
*Bangladesh Agricultural Research Institute, Rajshahi, Bangladesh*

*Infestation of litchi* (Litchi chinensis) *by fruit borer,* Conopomorpha sinensis *is severe in Bangladesh. Two separate experiments on varietal susceptibility and management, were conducted in randomised complete block design (RCBD) with three replications at the Fruit Research Station, Bangladesh Agricultural Research Institute (BARI), Rajshahi, Bangladesh to identify fruit borer tolerant litchi variety and to develop cost effective guidelines for managing this pest in 2018-19. Netting as protection as well as combination of spraying chemicals and bio-chemicals including sanitation was used as curative measures. Among all the management treatments, netting the whole plant with mosquito net of 40 mesh starting from pea stage (fruit setting) as well as sanitation (pruning of shader branches and removal of fallen leaves of the tree) plus spraying of imidacloprid 1 ml (20 SL product) per litre of water at pea stage (fruit setting) and spinosad 1.2 ml (2.5 EC product) at marble stage (developing) and at early ripening stage (twenty days before harvest) of fruit showed higher but statistically similar performance. Netting reduced 89 and 95 per cent borer infestation at developing and ripening stages respectively over control and it showed highest yield performance (4 071 fruits per plant) i.e.76 per cent healthy fruit yield increase over control and also highest (3.7) marginal benefit cost ratio (MBCR). The chemical treatment provided 64.86 and 82.95 per cent reduction of borer infestation at developing and ripening stages respectively over control. There was an increase of 76.16 per cent of healthy fruit yield over control and also 3.6 MBCR. These two guidelines were recommended among six eco-friendly management treatments. Results indicated that among the three common cultivated litchi varieties, China 3 was the most tolerant variety to fruit borer.*

***Keywords:*** *Litchi fruit borer,* Conopomorpha sinensis*, netting, spinosad, imidacloprid, litchi.*

There has been an increase in insect pests with the increasing intensity of various fruit productions in the present climatic situation in Bangladesh.

## LITCHI FRUIT

Litchi, *Litchi chinensis,* belonging to family Sapindaceae, is one of the most popular fruits rich in vitamins and minerals (USDA, 2019) and currently is being cultivated commercially in Bangladesh due to its high market demand and export potential. It is known as queen of the fruits due to its attractive deep pink/red colours and flavoured juicy aril. It also has a refreshing taste. Litchi fruit is consumed fresh and is also processed into various value-added products (*Figures 1 & 2*).

## FRUIT BORER OF LITCHI

Infestation of litchi fruits by fruit borer, *Conopomorpha sinensis* (Lepidoptera: Gracillariidae) larvae and rates of parasitisation by *C. sinensis* in litchi were severe in Bangladesh during the fruiting season (March to May).

The fruit borer attacks litchi fruits and causes devastation in south East Asia and southern China (Thanh *et al.*, 2006; Tran *et*

*Figure 1 A treated plant with non-infested litchi fruits*

*Figure 2 A bunch of non-infested litchi fruits*

*al.*, 2019). Females of *C. sinensis* prefer fruits than shoots for oviposition. If no fruit is available, they lay their eggs on shoots (Qinming *et al*., 2005; Schulte *et al.*, 2007). Temperature has a significant effect on oviposition, with most eggs being laid at 25°C (PengYan *et al*., 2013). In addition, the pupal period increases when the temperature declines. Pupal emergence rates are significantly higher at 20°C to 30°C. Suitable temperature and humid condition prevailing during litchi growing period enhances the infestation of this pest in Bangladesh.

## DAMAGE AND LOSSES

The fecundity of the litchi fruit borer feeding on litchi fruit is 160 eggs per female and the survival rate is 90.7 per cent (Qinming *et al*., 2005). *C. sinensis* is a small dark coloured moth (*Figure 3*). Female moths prefer to oviposit on the pericarp of fruits (*Figures 4 & 5*). Its larvae puncture the peduncle of the fruits and start feeding on the seed neck immediately and make holes filled with frass inside the nut, (*Figures 6 & 7*) which reduces fruit quality and causes dropping of fruits after infestation (Schulte, 2007; Tsang & Liang, 2007; Kumar *et al.*, 2014) and the leaves are the site of pupation (Garima *et al.*, 2020).

Litchi fruit borer is considered as a destructive pest causing significant economic losses and one of the major threats to litchi growers causing severe fruit loss as it has several generations right from initial stage to maturity (Kumar *et al.*, 2011). Kumar and Kumar (2007) also reported that litchi fruit borer infests 24-32 per cent of litchis at matured stage. Therefore, keeping in view the importance of litchi fruit borer, cost effective guidelines for managing against this fruit borer should be developed.

*Figure 3 Adult fruit borer,* C. sinensis

*Figure 4* *Litchi fruit infested by* C. sinensis *larva*

*Figure 6* C. sinensis *infested developing litchi fruit with frass*

*Figure 5* C. sinensis *pupa*

*Figure 7* C. sinensis *infested ripen litchi fruit with frass*

## PROTECTIVE AND CURATIVE MEASURES

Plant resistance to insect is one of the preferred protective ways that affects the biology or the behaviour of an insect or in which plant is able to recover the damage caused by insects (George, 1980). Covering the plants with mesh net is a non-lethal protective method (Aziz *et al.*, 2016) against insect infestation. But permanent netting is not viable as it may have detrimental effects on crop growth (Ullio, 2002). Regular pruning of shader branches for sufficient entry of sunlight and removal of fallen leaves as well as fruits for distraction of larvae and pupae are often seen as important cultural management strategies that reduce insect infestation and increase yield cost-effectively (Tollington *et al.*, 2019). Thus, use of pest resistant varieties, mosquito netting as well as pruning shader branches and removal of fallen fruits and leaves of the tree are incorporated as protective measures in the present study.

Like other crops, insecticides particularly organophosphates and carbamates are most powerful and widely accepted chemicals for the control of pests in litchi. However, excessive reliance on insecticides has posed several adverse effects such as pest resistance to insecticide, outbreak of secondary pests, harmful to non-target organisms, health hazards and problems related to environmental pollution. Menzel (2002) reported that *C. sinensis* cannot be controlled particularly due to its boring habit, but may be managed effectively with selective pesticide. Insecticides having low mammalian toxicity have been reported to be effective against various borers (Deshmukh *et al.,* 2010; Larrain *et al.,* 2014). In this regards, new generation insecticides and bio-pesticides could be options and would be suitable to be incorporated in an integrated pest management programme because they have selective actions, are less toxic (Qi & Casida, 2013) and do not contaminate the eco-system (Kuldeep *et al.,* 2004). Sometimes, a single pesticide does not control *C. sinensis* effectively whereas, alternate use of different pesticides perform well. So, selective chemicals and biochemicals should be applied at proper time and proper dosage given against litchi fruit borer as curative measures.

**Incorporated pesticides**

The biochemicals and chemicals incorporated against litchi fruit borer in the present study are mentioned below.

***Spinosad***

It is a fermented natural insecticidal product which is a mixture of two chemicals called spinosyn A and spinosyn D derived from the soil bacterial species, *Saccharopolyspora spinosa* (Frederick & Raymond, 1990). It is used to control a wide variety of pests (Bunch *et al.,* 2014) with both contact and systemic action (Mark *et al.,* 2011).

***Imidacloprid***

This is a systemic neurotoxin for insects, a mixture of different neonicotinoids (Gervais *et al.,* 2010) which protects trees from boring insects (Herms *et al.,* 2009).

***Emamectin benzoate***

It is a new insecticide which is the derivative of the soil actinomycete, *Streptomyces avermitilis* (Kaoukhov & Cousin, 2009), which acts strongly against lepidopteran insects (Fanigliulo & Sacchetti, 2008).

***Lufenuron***

This is a chitin synthesis inhibitor (insect growth regulator), used as an effective agricultural pesticide against lepidopteran insects and eriophyid mites (Paranjape *et al.,* 2014).

## MATERIALS AND METHODS

The present studies were conducted at the research field of Fruit Research Station, Bangladesh Agricultural Research Institute (BARI) during 2018-2019. The lands were well cultivated and fertilisers were applied as per recommendation of BARI. Mite infested leaves were pruned and abamectin (abamectin is a mixture of nerve poisons known as avermectins) was sprayed at 1 ml (% product) per litre of water in the months of June and October to manage litchi mite (*Eriophyes litchii* Acari) and mancozeb was sprayed at 2 g (% product) per litre of water three times at 15 days interval starting from marble stage to control anthracnose disease (*Colletotrichum gloeosporioides* Penz). Spraying was done using power sprayer. In the Control plant only water was sprayed.

**Host preference**

An experiment was conducted in a randomised complete block design (RCBD) with five replications to select tolerant litchi variety against fruit borer. Trees of three common cultivated varieties in Bangladesh *viz.* BARI Litchi-1, Bombai and China 3 were not covered with net for inviting fruit borer infestation up to harvest and kept free from pesticidal treatment against the fruit borer. Borer infestation was calculated harvesting 100 fruits of litchi from each replication.

**Management of litchi fruit borer**

Another experiment was laid out in RCBD with three replications to develop cost effective guidelines for managing litchi fruit borer (*Conopomorpha sinensis*). Six treatment packages against litchi fruit borer including untreated control were undertaken.

The treatments were as follows:

$T_1$= Netting of whole tree with mosquito net of 40 mesh starting from pea stage (fruit setting) of fruits (*Figure 8*);

$T_2$= Netting of whole tree with mosquito net of 40 mesh starting from marble stage (developing) of fruits;

$T_3$= Sanitation (pruning of shader branches and removal of fallen leaves of the tree) + spraying of imidacloprid 1 ml (20 SL product) per litre of water at pea stage as well as spinosad (1.2 ml 2.5 EC product) per litre water at marble stage and at early ripening stage of fruit (20 days before harvest) (*Figures 8 & 9*);

$T_4$= Sanitation + spraying of emamectin benzoate 1 g (5% SG product) per litre of water at pea stage as well as lufenuron 1 ml (5 EC product) per litre water at marble stage and at early ripening stage of fruit (20 days before harvest);

$T_5$= Sanitation + three sprays of emamectin benzoate 1 g (5% SG product) per litre of water at pea, marble stages, and early ripening stage of fruit (20 days before harvest), and

$T_6$= Untreated control.

During the fruit borer trial, each treatment was applied as mentioned above and observations were recorded on the basis of damaged fruit at developing as well as harvesting stages. To observe the borer infestation at developing stage, the fallen fruits were collected from a unit plant of each treatment (*Figure 10*) and cut with a sharp knife. At maturity, 100 fruits from each treatment and each replicate were plucked randomly and observed. The neck of the fruits was opened and presence of larval or their frass was considered as infested fruits. The number of healthy and infested fruits was recorded to calculate percentage of fruit infestation. The two formulae mentioned below were used for calculating percent increase or reduction over control.

Percent increase over control

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

Percent reduction over control

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

**Economic analysis**

Economic analysis was done on marketable yield of unit plant to assess the marginal benefit cost ratio (MBCR) of management practices.

**Statistical analysis**

Data were analysed statistically using Statistix10 software after appropriate transformations for proper interpretation. The data recorded on different parameters were subjected to analysis of variance (ANOVA) and means were compared using Duncan's Multiple Range Test (DMRT) at 5 per cent level of significance.

*Figure 8 Litchi tree covered with mosquito net and spraying of insecticide*

*Figure 9 Pruning of shader branches*

*Figure 10 Polyethene sheet spaded under litchi tree for collection of fallen fruit*

## RESULTS AND DISCUSSION

### Host preference

Borer infestation was highest (48%) in BARI Litchi 1 which did not differ statistically with Bombai (42%) whereas the least infestation (23%) was observed in China 3 variety (*Figure 11*). Cunningham (2012) observed the host choice behaviour of *C. sinensis* and stated that the female *C. sinensis* preferred a convex surface (*viz.* BARI Litchi 1 and Bombai) to a smooth surface (*viz.* China 3) for oviposition. Ohsaki and Sato (1994) and Ballabeni *et al.* (2001) also link similar oviposition behaviour for predator avoidance.

### Management of fruit borer

#### *Efficacy of treatments on fruit infestation at developing stage*

The developing fruit damage ranged from 2.7 to 24.7 per cent and recorded significantly different damages among the treatments (*Table 1*). The lowest fruit infestation (2.7%) was obtained from Treatment 1 followed by Treatment 3 (8.7%), Treatment 4 (13.7%) which did not differ statistically to Treatment 5 (14.7%) while highest fruit infestation was in untreated Control (24.7%) followed by Treatment 2 (19.0%).

The reduction of fruit infestation over Control incurred from 23.0 to 89.2 per cent among the treatments (*Table 1*). The highest reduction of fruit infestation of 89.2 per cent over Control was found in Treatment 1 followed by Treatment 3 (64.9%), Treatment 4 (44.6%) and Treatment 5 (40.5%) while that of lowest was in Treatment 2 (23.0%). The present results on the development of fruit infestation are closely similar to that of Bari and Sohel (2017) who reported that spinosad (45 SC product) showed the least fruit damage by fruit borer. The present study is strongly supported by findings of Rao *et al.* (2007) on legume pod borer, *Maruca vitrata* (Geyer) in pigeon pea and Singh *et al.* (2008) on insect pest complex on pigeon pea.

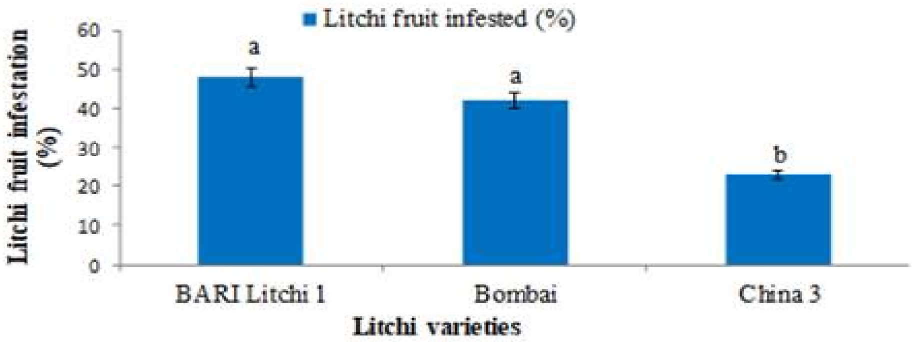


*Figure 11 Percent infestation of various litchi varieties by* C. sinensis *at Fruit Research Station, BARI, Rajshahi, Bangladesh during 2018-19 (Bars with same letter for each treatment denotes the damage was not significantly different at P <0.05%)*

### *Efficacy of treatments on fruit infestation ripening stage*

The fruit infestation at ripen stage ranged from 2.0 to 43.0 per cent and recorded significantly different damages among the treatments (*Table 1*). The lowest amount of infested fruits (2.0%) was collected from Treatment 1 followed by Treatment 3 (7.3%) which did not differ statistically with Treatment 2 (10.3 %). The percentage of fruit infestation of 19.3 and 27.0 was recorded in Treatment 4 and Treatment 5 respectively while the highest infestation (43.0%) was recorded in the Control.

Among the treatments, the reduction of fruit infestation over Control ranged from 37.2 to 95.4 per cent (*Table 1*). The reduction of fruit infestation was maximum (95.4%) in Treatment 1 which was closely related to Treatment 3 (83.0%), followed by Treatment 2 (77.0%), Treatment 4 (55.04%), whereas was minimum in Treatment 5 (37.2%). Jumroenma *et al.* (2004) reported that fruit bagging in litchi resulted in least percent damage of fruits at the harvesting period and also stated that spinosad (2.5 EC product) and imidacloprid (20 SL product) provided highly significant positive results against litchi fruit borer. Dolsopon *et al.* (2004) and Schulte *et al.* (2007) showed similar results, which is strongly supported by the present study.

### *Effect of treatments on yield*

The marketable yield (number of healthy ripen fruits/plant) ranged from 2 303 to 4 071 and recorded significantly different yields among the treatments (*Table 2*). The highest yield of 4 071 fruits per plant was obtained from Treatment 1 which did not differ significantly to the yield (4 057 fruits/plant) of Treatment 3 followed by Treatment 2 (3 621 fruits/plant) which was statistically similar with Treatment 4 (3 426 fruits/plant). The lowest yield was 2 303 fruits per plant which was obtained from the untreated Control plant followed by Treatment 5 (3 174 fruits/plant).

Maximum increase in marketable yield of 76.8 per cent over Control was achieved from Treatment 1 which was closely similar to Treatment 3 (76.2%) followed by Treatment 2 (57.2%). Inversely, the lowest percent yield increase over Control was found in Treatment 5 (37.8%) followed by Treatment 4 (48.8%).

TABLE 1

EFFICACY OF DIFFERENT TREATMENTS ON LITCHI FRUIT INFESTATION (%) IN BOMBAI VARIETY

| *Treatments* | *Fruit infestation (%)* | | *Reduction of fruit infestation (%) over control (number basis)* | |
|---|---|---|---|---|
| | *At developing stage* | *At ripening stage* | *At developing stage* | *At ripening stage* |
| $T_I$ | 2.7 e | 2.0 e | 89.2 | 95.4 |
| $T_2$ | 19.0 b | 10.3 d | 23.0 | 77.0 |
| $T_3$ | 8.7 d | 7.3 d | 64.9 | 83.0 |
| $T_4$ | 13.7 c | 19.3 c | 44.6 | 55.04 |
| $T_5$ | 14.7 c | 27.0 b | 40.5 | 37.2 |
| $T_6$ | 24.7 a | 43.0 a | 0.0 | 0.0 |
| LSD value | 3.110 | 5.004 | - | - |
| CV (%) | 12.31 | 15.14 | | |

Means followed by the same letters did not differ significantly by DMRT ($p<0.05$)

*Note:*

$T_I$= Netting of whole tree with mosquito net starting from pea stage.

$T_2$= Netting of whole tree with mosquito net starting from marble stage.

$T_3$= Sanitation + three sprays:1st of imidacloprid, 2nd and 3rd of spinosad of 2.5 EC product.

$T_4$= Sanitation + three sprays:1st of emamectin benzoate of 5% SG, 2nd and 3rd of lufenuron of 5 EC.

$T_5$= Sanitation + three spray of emamectin benzoate of 5% SG.

$T_6$= Untreated control

TABLE 2

EFFICACY OF DIFFERENT TREATMENTS ON LITCHI FRUIT YIELD IN BOMBAI VARIETY

| *Management practices* | *Number of healthy ripen fruits/plant* | *% Increase yield over control* |
|---|---|---|
| $T_I$= Netting of whole tree with mosquito net starting from pea stage | 4071 a | 76.8 |
| $T_2$= Netting of whole tree with mosquito net starting from marble stage | 3621 b | 57.2 |
| $T_3$= Sanitation + three sprays:1st of imidacloprid, 2nd and 3rd of spinosad | 4057 a | 76.2 |
| $T_4$= Sanitation + three sprays:1st of emamectin benzoate; 2nd and 3rd of lufenuron | 3426 b | 48.8 |
| $T_5$= Sanitation + three sprays of emamectin benzoate | 3174 c | 37.8 |
| $T_6$= Untreated control | 2303 d | 00.0 |
| LSD value | 222.37 | - |
| CV(%) | 3.55 | - |

Means followed by the same letters did not differ significantly by DMTR ($p<0.05$)

Dolsopon *et al.* (2004) and Jumroenma *et al.* (2004) stated that fruit bagging increased fruit yield due to having no effect on fruit dropping and Rao *et al.* (2007) recorded the maximum pod yield in pigeon pea applying spinosad (45 EC product) against pod borer. Similar results are obtained in the present study against litchi fruit borer.

TABLE 3
COST AND RETURN ANALYSIS OF DIFFERENT CONTROL MEASURES AGAINST LITCHI FRUIT BORER

| *Treatments* | *No. of fruit/plant* | *Gross return (BDT/plant)* | *Cost of treatment (BDT/plant)* | *Net return (BDT/plant)* | *Adjusted net return (BDT/plant)* | *MBCR* |
|---|---|---|---|---|---|---|
| $T_1$ | 4071 | 8142 | 750 | 7392 | 2786 | 3.7 |
| $T_2$ | 3621 | 7242 | 750 | 6492 | 1886 | 2.5 |
| $T_3$ | 4057 | 8114 | 760 | 7354 | 2748 | 3.6 |
| $T_4$ | 3426 | 6852 | 765 | 6087 | 1481 | 1.9 |
| $T_5$ | 3174 | 6348 | 793 | 5555 | 949 | 1.2 |
| $T_6$ | 2303 | 4606 | 0 | 4606 | - | |

*Note:*
$T_1$= Netting of whole tree with mosquito net starting from pea stage.
$T_2$= Netting of whole tree with mosquito net starting from marble stage.
$T_3$= Sanitation + Three sprays:1st of imidacloprid, 2nd and 3rd of spinosad of 2.5 EC product.
$T_4$= Sanitation +Three sprays:1st of emamectin benzoate of 5% SG, 2nd and 3rd of lufenuron of 5 EC.
$T_5$= Sanitation + Three spray of emamectin benzoate of 5% SG.
$T_6$= Untreated control

(*Note*: 1 BDT = 0.0125 USD) BDT means Taka

## Cost and return analyses

### *Economic analysis*

Economic analysis of the present study is shown in *Table 3*. It was observed that the highest (3.7) MBCR was calculated from Treatment 1 which was more or less similar (3.6) to Treatment 3 followed by Treatment 2 (2.5) and Treatment 4 (1.9). In contrast, the lowest MBCR (1.2) was recorded from Treatment 5.

### *Cost of relevant materials/activities*

The cost of materials and labour are as given below.

Cost of sanitation: twice with two workers at Taka. 25 per worker per tree;
Cost of mosquito net of 40 mesh*:* at Taka. 650 per plant per year;
Cost of covering the tree with net: at Taka. 100 per tree;
Cost of spinosad (2.5 EC product): at Taka. 260 per 100 ml;
Cost of emamectin benzoate (5 SG product): at Taka. 28 per 10g;
Cost of lufenuron (5 EC product): at Taka. 210 per 100 ml;
Cost of imidacloprid (20 SL product): at Taka. 600 per 400 ml;
Cost of spray: for three sprays at Taka. 50 per worker per tree per spray;
Cost of guard against thief and birds from open fruits: for 15 days at Taka. 25 per worker per tree per day;
Spray volume required: at 20 L of water per plant, and
Average price of fruit: at Taka. 2.00 per litchi at Khamerbari, Rajshahi.
(Note: 1 BDT = 0.0125 USD)

## CONCLUSION

Among all the treated litchi varieties, China 3 is the most tolerant variety to fruit borer. Considering percent reduction of fruit infestation and percent increase of yield over control and also highest MBCR, Treatment 1 or Treatment 3 may be recommended for effective management of fruit borers attacking litchi.

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