EVALUATION OF SOME NON-CHEMICAL AND CHEMICAL TACTICS FOR MANAGING LITCHI FRUIT BORER

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Abstract

Litchi damage is rated highly by the litchi fruit borer (LFB), causing substantial financial loss to the farmers which was minor a few years ago. This study aimed at evaluating 10 tactics for the management of LFB. Efficacies of the tactics were observed for two consecutive years, with the implication of treatments 15 days after the fruit set. The tactics performed better compared to the control. The hundred percent reduction of fruit infestations over control was with white waxed paper bag (T_3), followed by Cartap 50 SP (T_7: 96.10%), Sunmectin 1.8 EC (T_8: 94.86%) and neem leaf extract with mosquito net (T_2: 92.13%). The maximum number of healthy fruit was obtained from the treated tree of T_3 (100%), followed by T_7 (98%), T_8 (97.36%) and T_2 (95.96%). Among the treatments, the highest benefit-cost ratio (BCR) was 11.40:1 with neem leaf extract (T_4). Then second in neem oil (T_5: 9.99:1) followed by T_3 (8.72:1), karanja oil (T_6: 7.97:1) and T_8 (7.49:1). It was evident that application of neem leaf extract 15 days after fruit formation appeared as the most cost-effective tactics followed by white waxed paper bag. Therefore, for better management of litchi fruit borer, application of neem leaf extract (T_4) and white waxed paper bag (T_3) could be as eco-friendly and cost-effective tactics for healthy litchi production.

Keywords: Litchi, Fruit borer, Netting, Bagging, Botanicals, Insecticides

Introduction

Litchi (*Litchi chinensis Sonn*.) is a very important fruit crop under the order Sapindales and family Sapindaceae in the litchi-growing countries of the world (FAO, 2001). It is a commercial fruit worldwide, increasing demand at home and abroad every year for its tasty and nutritious status (Singh *et al*., 2019; Srivastava *et al.,* 2015; Vercammen and Schmitz, 2001). It grows well almost throughout Bangladesh. The major litchi-growing areas of Bangladesh are the greater Rajshahi, Dinajpur, Rangpur and Pabna districts (Siddiqui, 2002). Dinajpur produces high-quality litchi and its production is higher in the Pabna district (DAE, 2021). The number of litchi orchards is expanding in different regions of the country for higher demand and price comparable to other fruits in the market (Ahad *et al*., 2010). In 2019, over eighty thousand metric tons of litchi were produced from over thirty-one thousand acres of litchi orchards in Bangladesh (BBS, 2020). But the production of litchi fruit is hampered by the infestation of different insects-pest among them litchi fruit borer, *Conopomorpha sinensis* Bradley is the main damaging insect (Kumar *et al.,* 2014; Alam *et al.,* 2004; Waite and Hwang, 2002). Recently, it has been the most destructive pest for litchi in changing climate scenarios (Srivastava and Nath, 2015). The pest deteriorates

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the quality of fruit which is not consumable. The larva of the litchi fruit borer penetrates the young fruit through the seed and damages the mature fruit seed tip that causes fruit dropping (Ramakrishnaiah *et al.*, 2017; Huang *et al.*, 1994), leading to heavy financial loss to the farmers. It becomes serious, especially in humid conditions at the time of ripening (Taher, 2020; Hossain, 2011). The farmers of Bangladesh mainly depended on synthetic insecticides to manage litchi fruit borers like other crops (Taher *et al*., 2020; Alam, 2011). The frequency of spraying insecticides is increasing annually in the litchi orchard, which harms the environment and consumers' health (Roy and Karmakar, 2015). Due to the lack of effective and safe pest control methods for litchi farmers use pesticides indiscriminately and injudiciously without significant benefit (Taher *et al*., 2022e; Alam *et al.*, 2004). In case of fruits crops many alternative mechanical, biological and botanical tactics are being practiced (Sahoo *et al*., 2007; Dong *et al.*, 2006; Alam *et al.*, 2004) to manage damaging pests but do not follow those in the litchi pest control of Bangladesh (Taher, 2020). Excessive uses of insecticides destroys beneficial insects; develop insecticide resistance and increases consumer anxiety about health or life risks (Taher *et al*., 2022a; Alam *et al.*, 2019). The daily newspapers and health bulletin reported many children of age between two to ten died after eating insecticide-contaminated fruit during the litchi fruit season in the northern part of Bangladesh who lived near the orchard (IEDCR, 2012), which was supported by the findings of Roy and Karmakar (2015). The reported harmful toxicity levels in litchi fruit samples sprayed with overdoses of insecticides litchi. But it is possible to manage litchi pest mechanical techniques such as fruit bagging (Debnath and Mitra, 2008) and bio-pesticides. Fruit bagging can prevent almost all types of insects, diseases and external damage caused by weather, increasing the fruit's brightness and prolonging the harvest time (Taher *et al*., 2022b). Many developed countries use bagging/bio-pesticide to protect against pests in fruit production (Kumar *et al*., 2021; Sharma *et al.*, 2014), but its use is very limited in litchi in our country. If litchi is produced using those modern technologies, the risk caused by fruit poisoning will be reduced for eaters and farmers will be safe from the contamination of toxicity. Even beneficial insects will be protected, environmental pollution will be reduced and safe fruit production will be increased. The scope and volume of litchi export will be enhanced. Therefore, this research program was conducted to test the efficacy of bagging and neem extract over some chemical insecticides for the control of litchi fruit borer.

Materials and Methods

The research program was carried out in a litchi orchard (Variety: Madrazi and Bombai) in Bhutia village of Dhopakandi Union under Gopalpur Upazila in Tangail District of Bangladesh from March to June 2017 and 2018. Nine tactics such as T_1 = Mosquito net (2 mm mesh), T_2 = Neem leaf extract with mosquito net, T_3 = White waxed paper bag, T_4 = Neem leaf extract, T_5 = Neem oil, T_6 = Karanja oil, T_7 = Cartap 50 SP, T_8 = Sunmectin 1.8 EC and T_9 = Tracer 45 SC were evaluated over an untreated control (T_{10}). The experiments were laid out in a randomized complete block design with three replications. After 15 days of litchi fruit formation, the tactics were applied. Whole tree was covered with a mosquito net (T_1) for netting. Neem leaf extract was sprayed and covered with a mosquito net (T_2)

after drying the spray extract. A few fruit bunches were tied together with 50 fruits and inserted into each waxed-paper bag (T_3) for bagging. 1 kg of fresh neem leaves was mixed with the required amount of water and then boiled for 25-30 minutes after cooling and filtration, making a volume up to 5 litres, then sprayed (T_4: @ 20% w/v). Neem oil (T_5) and karanja oil (T_6) [@ 6 ml/L] were separately diluted into the water with dishwashing liquid (Trix mint) @ 0.5 ml per letter of water; the mixture was shaken for two minutes to prepare a uniform solution and then used as botanicals. Cartap (T_7), sunmectin (T_8) and tracer (T_9) with recommended doses were sprayed as insecticides. After the first spraying, botanicals were repeated in 3 at 10 days and insecticides 2 more times at 15 days intervals were sprayed with a foot pump sprayer in the afternoon. In the untreated control (T_{10}) trees were only sprayed with water. Each tactic (treatment) was applied to three trees at a time. Fifty ripened fruits from each replicate were harvested and the insect attack was observed by the opening base of the fruit petiole. External pits (Fig.1d) or Larva/larvae with excreta (Fig. 1e) or only excreta below the fruit peduncle (Fig. 1f) were considered as insect damage. The percentage of infestation per treatment was then calculated. The collected data were compiled and analyzed using MSTAT-C and Microsoft excel. DMRT (Duncan's Multiple Range Test) was performed to differentiate the efficacy levels of the treatment. The benefit-cost ratio (BCR) was calculated by dividing the total outcome by the expenditure for a treatment per acre of land.

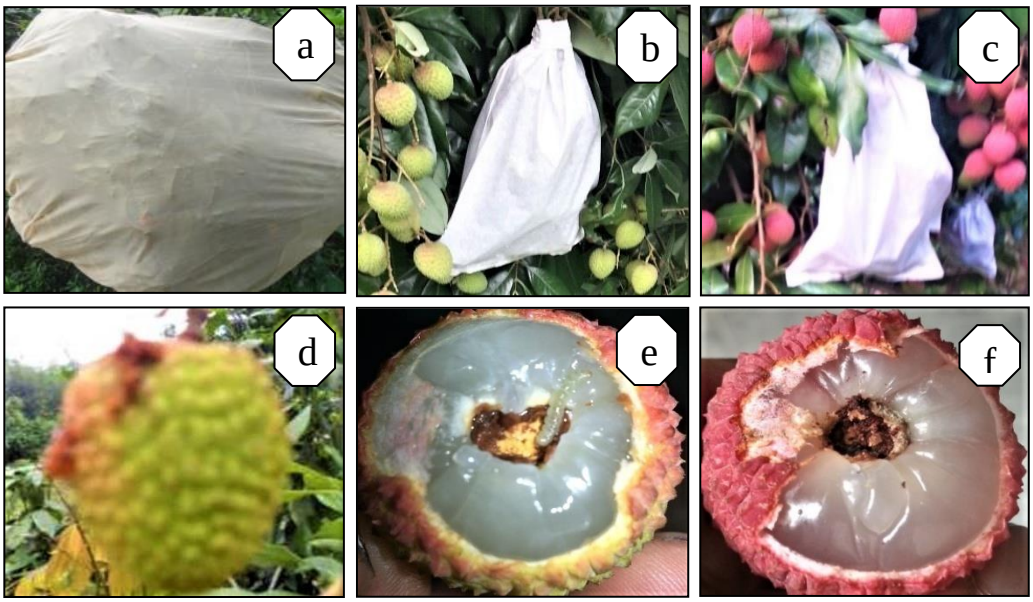

Fig. 1: Covering/bagging fruit bunches with (a) a mosquito net sheet and (b-c) a white waxed paper bag. Infested symptom of fruit (d) external pit with excreta, (e) excreta with larva below peduncle and (f) excreta on the seed tip

Results and Discussion

The results obtained by comparing the treated techniques and untreated control trees are presented in Table (1-3) and Fig. 2. All the treatments were more effective for controlling the litchi fruit borer (*Conopomorpha sinensis*) infestations as compared to untreated control and the present findings are discussed in the following headings.

Efficacies of netting and paper bagging to manage litchi fruit borer

During 2017, fully protected infestation was observed in treatment with bagging which was followed by neem leaf extract associated with mosquito net (5.00%) and sole mosquito net (8.09%) in harvested fruits (Table 1). Similar trends of infestations in all mechanical tactics against LFB were observed in 2018 (Table 2). Mean result revealed that bagging controlled the infestation completely followed by neem leaf extract combined with mosquito net (4.04%) and sole mosquito net (6.12%) (Table 3, Fig. 2). The highest benefit-cost ratio (8.72:1) was found in waxed-paper bagging and (<4:1; Table 3) in neem leaf extract combined with mosquito net and sole mosquito net.

Covering the tree with a perforated mosquito net leaving the lower side opened (Fig.1a) allowed insects to lay eggs, which inturn led to the infestation in the mosquito net. However, this was not the case with waxed paper bag, as the fruit was enclosed (Fig. 1b-c), which resulted the highest pest-free litchi fruit (Table 3). The present results are in consistent with many researchers who reported that the bagging technology is more efficient in producing more insect-free fruits (Chand *et al.,* 2020; Wang *et al.,* 2003; Kawabata and Nakamoto, 2013; Purbey and Kumar, 2015; Singh *et al*., 2019). It was speculated that the white waxed paper bag lets sunlight to enter through it supported the fruits' growth and development and prolonging harvesting time. Neem leaf extracts combined with mosquito net offered better results than the sole mosquito net. The neem leaf extract spray with mosquito net showed combined impacts of a physical barrier and deterrent impacts for lowering *C. sinensis* infestations.

Efficacies of botanicals to manage litchi fruit borer

With the botanicals during 2017, the higher infestation was found in karanja oil (17.00%) and the least (7.98%) in neem leaf extract followed by neem oil (9.64%) (Table 1). The infestation as compared with the previous year was dissimilar trends between neem oil (7.68%) and neem leaf extract (10.14%) but the same as with karanja oil (14.22%) (Table 2).

Mean results (2017-2018) showed that there was no significant difference in percent infestation between neem leaf extract (9.06%) and neem oil (8.66%) but karanja oil showed significant difference (15.61%) with all other tactics except the control treatment (Table 3). In queried that mean infestation reduction over control was found the highest in the treatment of white waxed paper bag (100%) followed by neem oil (83.13%) and neem leaf extract (82.35%), while the lowest (69.58%) in karanja oil-treated trees (Fig. 2).

Considering 2017-2018, more than 90 percent of healthy fruits were harvested from the treated trees of neem leaf extract and neem oil and >85% in karanja oil (Table 3). The highest calculated benefit-cost ratio (11.40:1) was for neem leaf extract followed by neem oil (9.99:1) and karanja oil (7.97:1).

All the botanicals used in this study were found to effectively reduce litchi fruit borer infestations compared to the control trees and the neem oil was the most efficient of all in terms of benefit-cost ratio (Table 3). Alam *et al*., 2004 and Miah *et al*., 2017 reported that neem oil was more effective in reducing litchi fruit borer infestations. Many researchers also reported that botanicals efficiently reduce LFB infestations (Sahoo *et al*., 2010; Shah, 2013; Laxmishree and Singh, 2017). The antifeedant and repellent actions of the botanicals keep LFB females away from egg laying on the young fruits, resulting in a higher reduction of fruit infestations over control (Taher *et al*., 2022c; Taher *et al*., 2020; Isman, 2006). Higher benefit-cost ratios were achieved from all botanical-treated trees compared to the controls, and the highest BCR was found for neem leaf extract treatment. Other researchers also reported similar results (Gupta *et al*., 2000; Amin, 2010). Reduced fruit dropping and a higher number of marketable fruits resulted in higher benefit-cost ratios.

Efficacies of insecticides to manage litchi fruit borer

The percent fruit infestations by the litchi fruit borer were significantly lower in all the insecticidal treated trees than in untreated control trees but showed not significant difference among the insecticidal treatments (Table 3). During 2017, the lowest percentage of infestation was recorded from sunmectin (0.66%) followed by cartap (2.00%) and tracer (3.66%) (Table 1). In 2018, a similar trend was observed with cartap (2.00%) followed by sunmectin (4.62%) and tracer (7.00%) (Table 2). Considering two years data, a maximum percent infestations reductions over control were found with cartap (96.10%) followed by sunmectin (94.86%) and then (89.61%) in tracer-treated trees (Fig.2). The highest BCR was found for sunmectin (7.49:1) but cartap and tracer had (>3:1; Table3).

Insecticides reduced LFB infestations significantly compared to the control trees (Table 3). The application of Cartap 50 SP was found as the most effective control option for litchi fruit borer. Possibly, cartap being a systemic insecticide was more efficient against LFB. Similarly, many researchers mentioned systemic insecticides as the most effective for controlling internal feeders like litchi fruit borer (Taher *et al*., 2022d; Purbey, 2016). Sunmectin treating technique was almost equally effective compared to cartap. Tracer and sunmectin were less effective than cartap in reducing infestations. It may be causing both (tracer and sunmectin) to be in contact mode of action. However, all insecticide treatments produced a higher number of marketable healthy fruits. But higher application costs of cartap and tracer decreased the profit margin and showed lower benefit-cost ratios. Incongruity in results among tactics between 2017 & 2018 may be due to the meteorological parameters, efficacy of tactics, mode of action, variety of litchi and price.

Table 1. Percentage of fruit infestations and production of fresh fruits under different techniques during 2017

Treatments	Fruit infestations (%)	Fresh fruits (%)
Mosquito net	8.09 cd	91.91
NLE + mosquito net	5.00 de	95.00
White waxed paper bag	0.00 f	100.00
Neem leaf extract	7.98 cd	92.02
Neem oil	9.64 c	90.36
Karanja oil	17.00 b	83.00
Cartap 50 SP	2.00 ef	98.00
Sunmectin 1.8 EC	0.66 f	99.34
Tracer 45 SC	3.66 ef	96.34
Control	53.30 a	46.70
Level of significance	0.01	-

Values having a common letter(s) within a column do not differ significantly at 5% level as per DMRT

Table 2. Percentage of fruit infestations and production of fresh fruits under different techniques during 2018

Treatments	Fruit infestations (%)	Fresh fruits (%)
Mosquito net	4.15 de	95.85
NLE + mosquito net	3.08 de	96.92
White waxed paper bag	0.00 e	100.00
Neem leaf extract	10.14 bc	89.86
Neem oil	7.68 cd	92.32
Karanja oil	14.22 b	85.78
Cartap 50 SP	2.00 e	98.00
Sunmectin 1.8 EC	4.62 de	95.38
Tracer 45 SC	7.00 cd	93.00
Control	49.34 a	50.66
Level of significance	0.01	-

Values having a common letter(s) within a column do not differ significantly at 5% level as per DMRT

Table 3. Mean percentage of fruit infestations, production of fresh fruits and benefit-cost ratios (BCR) under different techniques during 2017 and 2018

Treatments	Fruit infestations (%)	Fresh fruits (%)	Benefit-cost rations
Mosquito net	6.12 c	93.88	3.45:1
NLE + mosquito net	4.04 cd	95.96	3.53:1
White waxed paper bag	0.00 d	100.00	8.72:1
Neem leaf extract	9.06 c	90.94	11.40:1
Neem oil	8.66 c	91.34	9.99:1
Karanja oil	15.61 b	84.39	7.97:1
Cartap 50 SP	2.00 cd	98.00	2.99:1
Sunmectin 1.8 EC	2.64 cd	97.36	7.49:1
Tracer 45 SC	5.33 cd	94.67	2.35:1
Control	51.32 a	48.68	-
Level of significance	0.01	-	-

Values having a common letter(s) within a column do not differ significantly at 5% level as per DMRT

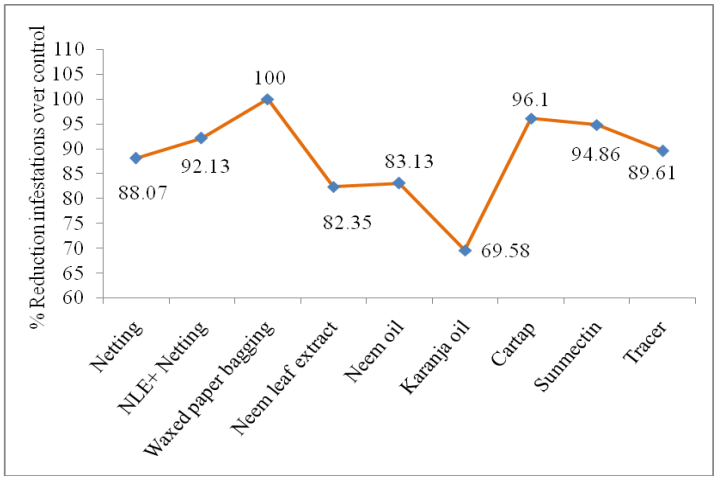

Fig. 2. Mean efficacy (2017-2018) of different approaches in the reduction of percentage of fruit infestations over control

Overall, it was found that white wax paper bags acting as a good physical barrier to protecting fruits from the litchi fruit borer achieved the highest number of healthy fruits; thus, a higher benefit-cost ratio was obtained among the physical protections. Notably, bagging fruits is safer for consumers and environment-friendly (Ali *et al*., 2021; Taher *et al*., 2022b). Botanicals do not cause disturbance to the environment, especially for non-target insects. Still, they can efficiently keep insects away from the fruits by the antifeedant and repellent actions to the target insects. The number of healthy fruit production and benefit-cost ratio obtained higher with the application of neem leaf extracts among the botanicals. The sunmectin exhibited higher infestation reduction over the controls. The highest benefit-cost ratio was obtained with the application of Sunmectin 1.8 EC. Therefore, considering the percent reduction of infestations, healthy fruit production and benefit-cost ratios, neem leaf extract appeared the most effective tactics followed by white waxed paper bags. Among the insecticides, Sunmectin 1.8 EC (Abamectin) appeared as cost-effective as it showed comparatively higher BCR compared to the other insecticidal treatments.

Conclusion

Litchi is a popular and high value fruit. At present, its production is severely affected by the attack of LFB. Farmers are harming the environment and threatening public health by repeated application of pesticides at excessive dose with short intervals to control this pest. But, LFB can be successfully controlled by applying Sunmectin 1.8 EC (Abamectin) 3 times at 15 days intervals after fruiting at the recommended dose. From this study it was found that application of neem leaf extract 15 days after fruit formation appeared as the most cost effective tactics followed by white waxed paper bags.

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