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Effect of fruit bagging on control damage of fruit borers and fruit quality of longan (*Dimocarpus longan* Lour.) cv. Eador

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Abstract

The study investigated the damage situation of fruit borers on longan in Dong Thap, Tien Giang, and Vinh Long provinces and evaluated the effect of different fruit bagging materials on preventing harmful fruit borers and fruit quality of longan cv. Eador during 2019-2020. The experiment arranged in a randomized complete block design (RCBD) four replications and five treatments. The treatments were non-woven bag, Bikoo micro-hole bag, Agro-net bag (49 holes.cm⁻²), white cotton bag, and control (uncovered fruits). The investigation indicated that fruit borers appeared and caused damage fruit from 2 weeks after fruit set to harvesting time. The percentage of infected fruit of longan orchards were high at 4 weeks after fruit set (1.75%) in Dong Thap, and in Tien Giang, Vinh Long provinces at 10 weeks after fruit set (1.46% and 2.04%, respectively). During 12 weeks from fruit bagging to harvest, bagging of fruits by four types of material did not damaged by fruit borers. However, control treatment increased the rate of infected fruits continuously (7.22% at harvest time). Agro-net bag (49 holes.cm⁻²), Bikoo micro-hole bags, and white cotton bag were low fruit drop rate (30.73%, 30.65%, and 32.11%) when compared to control (47.14%). From the results obtained conclusion that application of fruit bags on longan cv. Eador was highly effective in preventing damage from fruit borers and ultimately production free from pesticides residues.

Keywords: Bagging, fruit borer, fruit quality, longan cv. Eador, Vietnam

Introduction

The longan [*Dimocarpus longan* Lour. (Sapindaceae)] Was a perennial fruit tree (Waite and Hwang, 2002) [27]. China, Thailand, and Vietnam are major producers of longan. Longan was planted over an area of 73,600 ha in Vietnam and it is the fifth most cultivated fruit crop after mango, banana, pomelo, and the second most exported crop behind dragon fruit (Department of Crop Production, 2017) [11]. Longan is cultivated mostly in Vinh Long, Tien Giang, and Dong Thap provinces of Southwest Vietnam. Yellow peach moth *Conogethes punctiferalis* Guenée (Lepidoptera: Crambidae) is one of the major pest of longan in Vietnam (Hanh *et al.*, 2019) [16]. *Conogethes punctiferalis* is widely distributed in the South and East Asia, Australia, and Papua New Guinea (CABI 2011) [9]. Fruit borers appeared after fruit set to harvest caused damage to the quality and yield of longan. Fruit bagging is one of the effective method to protect the fruit from the attack of many pests and diseases. It greatly reduced the number of chemical spraying times by farmers, limiting chemical residues on post-harvest products. In Japan, China, Korea, Australia and the USA fruit bagging is an integral part of fruits for domestic and export markets because it is a safe and eco-friendly technique to protect fruits from multiple stresses, preserving or improving the overall quality (Ali *et al.*, 2021) [3]. Fruit bagging has been applied on many fruit trees in Vietnam such as mango, guava, rambutan, pomelo. Fruit bagging were effective in the management of the *Cerconota anonella* fruit borer (Bustillo and Pena, 1992) [7]. Fruit bagging used extensively in Asia as a physical protection method to reduce pest problems (Hoying *et al.*, 2006) [18]. Fruit bagging is considered an effective measure to control fruit borer *Nephopteryx* sp. (Biosecurity Australia, 2010) [6]. The materials commonly used in the production of fruit bags include kraft-type paper, baking paper, polyethylene, micro-perforated polypropylene, and polypropylene spun-bond fabrics (Abbasi *et al.*, 2014; Bilck *et al.*, 2011, Liu *et al.*, 2015, Zhou *et al.*, 2019) [1, 5, 20, 29]. Fruit bagging is one of the eco-friendly techniques and its many beneficial effects, fruit

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bagging has become an integral part of peach, apple, pear, grape, and loquat, litchi cultivation in Japan, Australia, China, and the USA (Sharma *et al.*, 2014) [25]. Fruit bagging in mango, and pomegranate to protect fruits from pest and diseases and also to improve the quality of fruit (Haldankar *et al.*, 2015 and Akter *et al.*, 2020, Gethe *et al.*, 2021) [14, 2, 12]. This paper discussed the damage rate of fruit borers on longan cv. Eador after fruit set and the effect of fruit bagging to control damage of borer and fruit quality.

Materials and Methods

Study site

A study on the damage situation of fruit borers on cv. Eador longan orchards and fruit bagging experiment were conducted in Dong Thap province (An Phu Thuan village, Chau Thanh district), Vinh Long province (Hoa Ninh village, Long Ho district), Tien Giang province (Tan Phong village, Cai Lay district) of Mekong Delta River, Vietnam. Each province, five Eador longan orchards from 5 to 7 years old were selected to assess the damage rate of fruit borers at different stage. On each orchard selected 10 trees for monitoring.

Fruit bags experiment

The field experiment performed at 7 years old cv. Eador longan orchard in Hoa Ninh commune, Long Ho district, and Tien Giang province. The orchard planted at a spacing 3.0 m between trees and 3.5 m between rows. All longan trees received similar cultural practices such as irrigation, fertilization and induce flowering. The experiment conducted in randomized complete block design (RBCD) with five treatments and four replications. The five treatments including Non-woven bag, Bikoo micro-hole bag, Agro-net bag (49 holes.cm⁻²), White cotton bag and uncovered fruits (control treatment). The size of the bag was 30 x 50 cm. Fruit clusters bagged at 4 weeks after fruit set. Ten fruit clusters randomly selected per treatment per replication for recording different observations. Fruit physical characteristics and fruit quality analyzed at Fruit Analysis Laboratory of Southern Horticultural Research Institute.

Assessed parameters

Data on the damage situation of fruit borers on cv. Eador longan orchards recorded at 2 weeks after fruit bagging to fruit harvesting. The percentage of infected fruit and the

percentage of fruit drop calculated at an interval of 2 weeks/time. The fruit quality recorded at harvest time (samples of ten fruit clusters from each treatment selected) as following formula

Percentage of infected fruit (%) = (Total infected fruits/Total observed fruits) x 100

Percentage of fruit dropping (%) = (Total number of dropped fruit per cluster/Total observed fruits per cluster) x 100

Fruit physical and fruit quality characteristics: Samples of ten fruit clusters from each treatment devoted to determine the following as weight of fruit, weight of fruit clusters, fruit size, peel color, total soluble solids.

The color of the peel was determined using a Minolta colorimeter (L*a*b* system). L* (luminosity), a* (the green-red variation degree) and b* (the blue-yellow variations degree) values were obtained.

Total soluble solids (%) content was measured by hand refractometer (Atago, Japan) and expressed in Brix (0 to 32°Brix).

Data analysis

Data collected and analyzed using analysis of variance (ANOVA), and Duncan's Multiple Range Test (DMRT) used for means comparison when treatments were significant by using MSTATC program.

Results and Discussions

The damage situation of fruit borers on cv. Eador longan orchards

Survey on longan cv. Eador orchards aged 5 - 7 years in Dong Thap, Vinh Long and Tien Giang provinces. The results indicated that the longan fruit borers appeared and caused damage to fruit from 2 weeks after fruit set up to fruit harvest (16 weeks after fruit set). The rate of infected fruits was high at 4 weeks after fruit set (1.75%) in Dong Thap, 10 weeks after fruit set (1.48%) in Tien Giang, and (2.04%) in Vinh Long, and the rate of infected fruits gradually decreased until 16 weeks after fruit set (0.21%, 0.26%, and 0.51% in Dong Thap, Tien Giang, Vinh Long, respectively). Two major fruit borer species appeared during the survey as *Conogethes punctiferalis* and *Deudorix epijarbas* (Plate 1 and Plate 2).

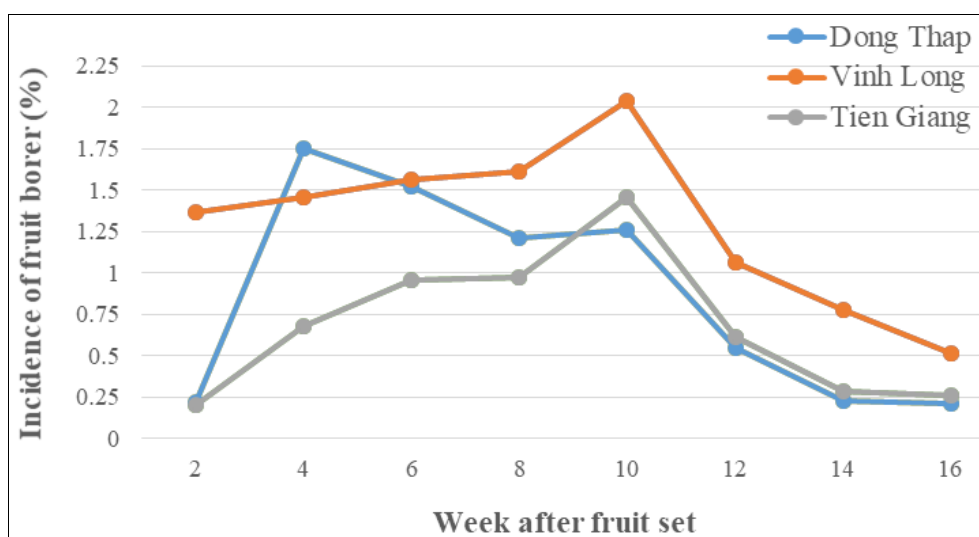


Fig 1: Percentage of infected fruit at fruit stage in longan cv. Eador orchards

Effect of different fruit bag materials on the percentage of damage of fruit borers

The result from Table 1 indicated that all treatments covered with different bag materials were not attacked by fruit borers from 2 week after bagging up to harvest but there were significantly differences among bagging treatments to control treatment (uncover fruit). The percentage damage of fruit borers in bagging treatments were 0%. The control treatment the infection rate gradually increased up to the harvest time. The percentage of damage of fruit borers in control treatment was 0.20% at 2 weeks after bagging and 7.22% at harvesting. For most insect pests, bagging provided equivalent levels of fruit protection when compared with the conventional pesticide spray program (Daniel, 2018) ^[10]. Pre-harvest

bagging in mango reduced the use of pesticide in the fruit (Amarante *et al.*, 2002) ^[4] and prevented insects (Sarker *et al.*, 2009) ^[24]. Previous studied examining fruit bagging including nylon mesh, and polypropylene fabric could be used to protect fruit from insect pests (Teixeira *et al.*, 2011; Grasswitz *et al.*, 2013; Sharma *et al.*, 2014) ^[26, 13, 29]. Karara *et al.* (2019) ^[19] indicated that the attack of fruit flies and other insect-pests were not effect in bagged mango fruits and litchi fruit clusters (Purbey and Kumar, 2015) ^[23]. Fruit bagging is an effective alternative to replacing the use of agrochemicals - fungicides and insecticides that can threaten the safety of workers in the horticultural industry and the health of consumers (Buthelezi *et al.*, 2021) ^[8].

Table 1: The percentage of infected fruit on longan cv. Eador after fruit bagging to harvest

Treatment	The percentage of infected fruit (%) (Week after bagging ^X)										
	2	3	4	5	6	7	8	9	10	11	12
Non-woven bag	0	0	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b
Bikoo micro-hole bag	0	0	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b
Agro-net bag (49 holes.cm ⁻²)	0	0	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b
White cotton bag	0	0	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b	0 ^b
Control (uncovered fruit)	0.20	1.32 [*]	1.42 ^a	2.54 ^a	3.46 ^a	4.17 ^a	4.88 ^a	6.00 ^a	6.81 ^a	7.12 ^a	7.22 ^a
Level of significance	ns	*	*	**	**	**	**	**	**	**	**

In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT), ns = not significant. ^XFruit clusters were bagged at 4 weeks after fruit set.

Effect of types of bag on fruit physical characteristics and fruit quality of longan cv. Eador

The data fruit weight, fruit diameter, fruit weight of cluster at harvest recorded in Table 2. Regarding fruit weight, fruit diameter and fruit weight of cluster there were not significantly different among bagging treatments and control. However, there were significantly different in fruit drop rate per cluster of treatments Plastic net bag (49 holes.cm⁻²) (30.65%), Bikoo micro-hole bag (30.73%), White cotton bag (32.11%) when compared to Non-woven bag (35.38%) and control (47.14%) (Table 2). Yang *et al.* (2009) ^[28] studied clusters of cross-winter off-season longan (*Dimocarpus longan* Lour.) cv. Chuliang were bagged at 34 days after anthesis with three types of bags. All bag types tended to increase in larger sized fruit and the final fruit retention rate did not significantly affected by bagging. Covering fruit at 35 days after fruit set in mango cv. Cat Chu with two layer paper bags, glossy paper and Bikoo bags reduced the rate of fruit drop (Hang and Hong, 2015) ^[15]. Fruit quality as measured by fruit diameter of apple was not significantly different among treatments (Daniel, 2018) ^[10].

Regarding luminosity and color of fruit based on the L*a*b*

system, colors are three-dimensionally represented. The L* coordinate indicates luminosity, ranging from zero (completely black) to 100 (completely white). Value a* coordinate expresses the green-red variation degree and b* coordinate expresses blue-yellow variation degree. Results from Table 3 indicated that the types of bagging materials were not affect the brightness and darkness of the peel color. The L*a*b* were not significantly different among types of bagging treatments compared to control treatment (without bag). The change in color of the fruit was a signal that the fruit was maturity. Total soluble solids were not significantly different among types of bagging treatments and control treatment (without bag). There were no change in total soluble solids of fruit bagging and without bagging. The TSS of longan cv. Eador was not statistically significant among treatments and measured 19.64%-20.27%.

The time from fruit set to the fruit color changing turned from green to yellow ranges from 80 to more than 100 days depending on the varieties reported by Norlia (1997) ^[21]; Pungtip (2009) ^[22]. Different bag materials did not change on the total soluble solid (%) were studied on mango (Hau *et al.*, 2013 and Hang and Hong, 2015) ^[17, 15].

Table 2: Effect of different fruit bag materials on fruit weight, fruit diameter, fruit cluster weight, and fruit dropping

Treatment	Fruit weight (g)	Fruit diameter (mm)	Fruit weight of cluster (g)	Fruit drop rate/cluster (%)
Non-woven bag	9.58	26.87	591.62	35.38 ^{ab}
Bikoo micro-hole bag	9.76	27.19	602.35	30.73 ^b
Agro-net bag (49 holes.cm ⁻²)	9.06	26.23	587.37	30.65 ^b
White cotton bag	8.15	25.72	516.71	32.11 ^b
Control (uncovered fruit)	8.74	26.89	503.42	47.14 ^a
Level of significance	ns	ns	ns	**

In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT), ns = not significant.

Table 3: Effect of different fruit bag materials on fruit peel color, total soluble solids

Treatment	Color of fruit peel			TSS (%)
	L*	a*	b*	
Non-woven bag	51.25	3.09	36.32	20.13
Bikoo micro-hole bag	50.71	3.65	36.20	20.27
Agro-net bag (49 holes.cm ⁻²)	50.23	3.60	35.99	19.64
White cotton bag	52.29	2.90	37.73	19.95
Control (uncovered fruit)	50.79	3.60	36.93	19.85
Level of significance	ns	ns	ns	ns

In a column, means followed by same letters are not significantly different at 5% probability level by Duncan's Multiple Range Test (DMRT), ns = not significant.

**Plant 1:** Lavar and symptom damage of conogethes punctiferalis on longan fruit**Plant 2:** Lavar and symptom damage of Deudorix epijarbas on longan fruit

Conclusion

The result revealed that fruit borers appeared and caused damage to longan fruit from 2 weeks after fruit set up to harvest and the percentage of infected fruit was high at 4 and 10 weeks after fruit set in Dong Thap, Tien Giang, and Vinh Long provinces. The fruit clusters bagging at 4 weeks after fruit set with four types of materials did not damaged by fruit borers. Uncovered fruit clusters increased incidence of borer continuously up to harvest time). In conclusion, the application of fruit bags on longan cv. Eador was highly effective in preventing damage of fruit borers and ultimately product of fruit free from pesticides residues.

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