



Effect of Bagging Time on Fruit Yield and Quality of Red Pitaya (*Hylocereus spp.*) Fruit in Vietnam

Nguyen Minh Tuan^{1*}, Nguyen The Hung², Bui Lan Anh¹, Nguyen Quoc Hung³,
Nguyen Viet Hung¹, Tran Trung Kien¹, Tran Thi Lien¹ and Do The Viet⁴

¹Department of Agronomy, Thai Nguyen University of Agriculture and Forestry, Quyet, Thang Commune, Thai Nguyen City, Vietnam.

²Faculty of Environment, Thai Nguyen University of Agriculture and Forestry, Quyet, Thang Commune, Thai Nguyen City, Vietnam.

³Fruit and Vegetable Research Institute, Ha Noi, Vietnam.

⁴Horticulture Research and Development Center, Nomafsi, Vietnam.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was performed to evaluate the effect of bagging time on fruit yield and quality of red pitaya H14 cultivar from May to August 2017 at Nguyen Binh District, Cao Bang Province, Vietnam. The experiment design was in Randomized Complete Block Design with three replicates, including control (without bagging), bagging fruit after 7 days anthesis, bagging fruit after 15 days anthesis by net screen-green bag (NS-GB) with bag size 320 x 260 mm. The physical, biochemical quality characteristics and damage of the fruits were recorded. The results showed that there was no significance in fruit number and fruit yield, fruit size among treatment by application bagging fruit. Moreover, bagging fruit after 7 days anthesis greatly improved flesh fruit weight, fruit edible rate percentage as well as total soluble solid than the control treatment. Furthermore, bagging fruit after 7 days anthesis markedly reduced 10-20% fruit crack, fruit sunburn, fruit fly and fruit blemished as

*Corresponding author: E-mail: tuan_dhnl@yahoo.com, nguyenminhtuan@tuaf.edu.vn;

compared to control treatment. In conclusion bagging fruit after 7 days anthesis had positive effect on enhancing fruit quality (total soluble solid increase 15% as compared untreated control) and reduced fruit from insect pest and diseases for red pitaya cultivar under field condition in Cao Bang province, Vietnam.

Keywords: Red pitaya cultivar; fruit fly; bagging fruit; fruit damage.

1. INTRODUCTION

Dragon fruit, also known as pitaya (*Hylocereus costaricensis* [F.A.C. Weber] Britton & Rose) is a climbing fast growing perennial vine cactus species which is originated in Mexico and Central and South America [1]. It is currently being marketed worldwide and cultivated commercially fruit crop at least 20 countries including Vietnam [2]. The dragon fruit is a large, oblong fruit with a red peel and large green scales. The flesh is sweet, delicate, red purple, and contains numerous tiny black seeds. The fruit is nonclimacteric and has the best flavor when harvested at full red color [3]. Dragon fruit is rich in vitamins, minerals and fibers that helps the digestive process, prevent colon cancer and diabetes, neutralize toxic substances such as heavy metals, and helps to reduce cholesterol levels and high blood pressure [4].

In agriculture, fruit growth and quality influenced by the environment, several physical and chemical changes such as insect pest infestations, bird attack, various pathogens, and mechanical damage, which can reduce their commercial value and thereby cause significant yield and economic losses. Bagging is a physical protection technique, commonly applied to many fruit, which not only improves their visual quality by promoting peel colouration and reducing the incidence of fruit cracking and russeting, but can also change the microenvironment for fruit development [5], which can have multiple effects on internal fruit quality. Many reports indicated that bagging has been used extensively in several fruit crops to improve skin colour and to reduce the incidence of disease, insect pests, mechanical damage, sunburn of the skin, and bird damage to increase market value [6,7,8,9, 10,11,12]. Reference [13] also proved that fruit bagging has been used for the production of high quality, unblemished Asian pear fruit. Due to its many beneficial effects, fruit bagging has become an integral part of peach, apple, pear, grape and loquat cultivation in Japan, Australia, China and the USA. Moreover, countries such as

Mexico, Chile and Argentina do not import apples unless they are bagged [14]. Nowadays, fruit bagging has been a conventional practice in many kind of fruit such as guava, citrus cultivars in Vietnam, however, the knowledge of bagging fruit for pitaya fruit so far lacking. So, the objective of this experiment was to carry out to determine the effect of bagging time fruit on fruit yield and quality of red pitaya at Cao Bang province, Vietnam condition.

2. MATERIALS AND METHODS

2.1 Plant Materials and Experiment Treatments

The experiment was carried out at red pitaya fruit orchard, Nguyen Binh District, Cao Bang Province, Northern mountainous Vietnam (22°39'34.08"N, 105°57'50.8"E) from May to August 2017. Red flesh pitaya H14 cultivar is result of hybridization between white flesh pitaya (Vietnam) and red flesh pitaya (Colombia). The red flesh pitaya H14 has good fruit shape, bright red peel, rather firm flesh, sweetness, fruit weight 300-400g. The H14 red pitaya cultivar 4 years old with the red peel-red pulp was chosen for the experiment. Twenty seven pillars about the same length and diameter were selected for the experiment. The experiment consists of three treatments including control (without bagging), bagging fruit after 7 days anthesis, bagging fruit after 15 days anthesis by net screen-green bag (NS-GB) with bag size 320 x 260mm. The experiment design was in Randomized Complete Block Design with three replicates. Amount of rainfall around 247.0-253.4 mm.

2.2 Data Collection

Fruit number per pillar was measured by counted. Fruit length was measured from the part attached to the petiole to the base of the fruit. The fruit diameter measurement recorded was the average of two readings taken at two axes of the midsection of the fruit. Peel thickness was determined at the equatorial point of fruit

with a digital caliper. Average fruit weight, peel weight, flesh fruit weight were determined by weighing and the edible flesh percentage was calculated. Total yield were determined by counting the total number of fruits per pillar. Fruit damage caused by cracking, sunburn, blemishes and fruit fly were recorded and expressed as percentage. Total soluble solid (TSS) were measured by using a hand refractometer (ATAGO Co. LTD., Tokyo, Japan) juice was squeezed from a sample of the middle of fresh-cut fruit and the result was expressed as °Brix.

2.3 Statistical Analysis

The data obtained from the study were analyzed using SAS 9.1 statistical software. The least significant difference was calculated following a significance F-test (at $p \leq 0.05$)

3. RESULTS AND DISCUSSION

3.1 Effect of Bagging Time on Fruit Number and Fruit Yield

The results summarize in Table 1 showed that bagging fruit after 7 days anthesis treated were found to have the highest number of fruit (13.67 fruit number/pillar), whereas the lowest fruit number (11.55 fruit number/pillar) recorded in untreated control, although the difference was not statistically ($p \leq 0.05$), which is in accordance with the finding of [15]. The same data in Table 1 indicated that there was no significant difference in fruit yield between bagging treatments and the control, although bagging fruit after 7 days anthesis showed the highest fruit yield (4.94 kg/pillar) among all treatments (Table 1). Thus, the relationship of fruit bagging treatment to the fruit number and fruit yield are variable and not yet clearly established.

3.2 Effect of Bagging time on Fruit Characteristics

Many references proved that fruit bagging had no effect on fruit size in mangoes [8], pears [6,16], and no influence on fruit weight in mangoes [9], lychees [11] or pears [6]. Therefore, the results presented in this study showed that no significant differences among treatment in fruit weight, peel fruit weight, peel thickness and fruit size (fruit length and fruit diameter) as compared to untreated control (Table 2). It seem that bagging fruit no effect on fruit size and weight for red pitaya in this study due to changes of temperature or humidity in fruit bags did not significantly affect fruit size and weight, which is in accordance with the finding of [17]. Moreover, there were significant differences among treatments concerning flesh fruit weight (Table 2). In contrast bagging fruit after 7 days anthesis treatment showed the highest flesh fruit weight (247.35 g), followed by bagging fruit after 15 days anthesis treatment with value of 231.29 g, whereas the control treatment had the lowest flesh fruit weight which recorded as 169.63 g. This result is in agreement with the findings of [18] who reported that bagging with plastic bags increased fruit weight in carambola when applied 10 days after full bloom. The same data presented in Table 2 showed that there was significant differences in fruit edible rate percentage for all treatment in this study. In term, the lowest edible rate percentage of fruit (58.34%) was found in the control treatment, while the highest edible rate percentage of fruit (68.60%) was observed in bagging fruit after 7 days anthesis. Moreover, bagging fruit after 15 days anthesis treatment also increased edible rate percentage of fruit compared with control treatment (Table 2), which is in accordance with the finding of [17]. Therefore, from the data in present study it can be suggest that bagging treatment greatly increased edible rate percentage of red pitaya fruit.

Table 1. Effect of bagging time on fruit number and fruit yield of red pitaya cultivar*

Treatment	Fruit number (fruit number/Pillar)	Yield (kg/Pillar)
Control	11.55	3.83
Bagging fruit after 7 days anthesis	13.67	4.94
Bagging fruit after 15 days anthesis	11.11	3.89

* Mean in each column followed by the same letters are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test

Table 2. Effect of bagging treatment on fruit character of red pitaya cultivar*

Treatment	Fruit weight (g)	Flesh fruit weight (g)	Peel fruit weight (g)	Flesh thickness (cm)	Peel thickness (cm)	Fruit length (cm)	Fruit diameter (cm)	Edible rate (%)
Control	284.65	169.63	115.02	7.09	0.27	10.09	7.37	58.34 ^b
Bagging fruit after 7 days anthesis	357.71	247.35	110.36	7.19	0.22	10.16	7.63	68.60 ^a
Bagging fruit after 15 days anthesis	344.26	231.29	112.97	7.14	0.27	10.44	7.19	66.32 ^a

* Mean in each column followed by the same letters are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Table 3. Effect of bagging treatment on physically damage, percentage defective fruit and fruit quality in red pitaya cultivar

Treatment	Fruit crack (%)	Fruit blemished (%)	Fruit fly (%)	Fruit Sun burnt (%)	TSS Content (^o Brix)
Control	25.00 ^a	19.45 ^a	27.78 ^a	27.78 ^a	11.55 ^b
Bagging fruit after 7 days anthesis	5.55 ^b	5.55 ^b	2.78 ^b	5.55 ^b	13.28 ^a
Bagging fruit after 15 days anthesis	8.33 ^b	8.33 ^b	8.33 ^b	11.11 ^b	12.15 ^b

* Mean in each column followed by the same letters are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

3.3 Effect of Bagging Time on Fruit Damage and Fruit Quality

Fruit cracking is caused by a number of reasons. Drought, hot temperature, heavy rain and high humidity have been reported to induce fruit cracking in litchi and longan [19]. As showed in the Table 3, fruit cracking was statistically ($p \leq 0.05$) between control and other treatments in this study. Bagging fruit after 7 days anthesis, and bagging fruit after 15 days anthesis application treatments significantly lessened fruit cracking as compared with the control. The results suggest that bagging time treatments were effective in prevention of fruit cracking. Similar finding had been reported by [20]. The same data from Table 3 indicated that there was significant fruit blemished among treatments ($p \leq 0.05$). In term, bagging fruit after 7 days anthesis gave the lowest fruit blemished (5.55%), followed by bagging fruit after 15 days anthesis with value of 8.33%, while the highest fruit blemished (19.45%) was recorded in untreated control. It seems that fruit bagging also prevents diseases from reaching the developing fruit, which protects them from several diseases that can cause major losses. Thus, in the present study applied fruit bagging can be a beneficial practice for producing higher quality fruit, without or with less use of chemicals to control diseases, which is in accordance with the finding of [14].

Physiological disorders are anomalies in the fruit which are not caused by insect damage or pathogen invasion, but are the result of a deficiency or an excess of a nutrient, low or high temperatures, or high or low rates of ethylene production or respiration [21]. So, in this study, the data in Table 3 also indicated that the maximum fruit sunburn was found in control treatment (27.78%), whereas the minimum fruit sunburn was obtained in control treatment (11.11%). It seems that bagging fruit reduce the incidence of sunburn in fruit. Similar results were reported by [10] who indicated that fruit bagging has been used extensively in some countries to reduce the problems of sunburn and fruit cracking.

Fruit bagging is a good technique to maintain a physical separation between the environment and the the product. One of the most significant effects of fruit bagging has been protection from the damage caused by fruit fly. Several studies have indicated that bagging reduced the incidence of fruit fly in guava [22], mango [8,23].

From the data in Table 3 indicated that there was significant differences in fruit fly damage among treatment ($p \leq 0.05$). In construct, bagging fruit after 7 days anthesis gave the lowest fruit fly (2.78%), followed by bagging fruit after 15 days anthesis with value of 8.33%, whereas the highest fruit fly (27.78%) was recorded in untreated control. It seem that the bags act as a physical barrier between the fruit flies and the fruit, hence, minimizing the attack and losses to the fruit. Thus, our study can be suggest that bagging fruit greatly decreased fruit fly (Table 3).

Reference [7] reported that sweetness in 'Granny Smith' apple fruit was improved by bagging in brown paper bags at the golf-ball size of fruit development. From the results presented in study, the total soluble solid in all treatment were higher significantly than the control treatment, in term the highest total soluble solid value of 13.28 ($^{\circ}$ Brix) was observed in bagging fruit after 7 days anthesis treatment. The minimum total soluble solid in untreated control was 11.55 ($^{\circ}$ Brix) (Table 3). It seems that bagging fruit increase total soluble solid in fruit. Therefore, our study indicated that bagging fruit after 7 days anthesis treatment greatly enhancing in TSS, which is in accordance with the findings of [24,25].

4. CONCLUSIONS

From the experiment results, it can be concluded that bagging fruit after 7 days anthesis greatly improve flesh fruit weight, fruit edible rate percentage as well as total soluble solid. The results also suggested that bagging fruit after 7 days anthesis markedly decreased fruit crack, fruit sunburn as well as fruit damage from fruit fly and fruit disease for H14 red pitaya cultivar. Hence, bagging fruit after 7 days anthesis could be recommended a valuable tool for improving quality and reduced fruit damage for red pitaya under Nguyen Binh District, Cao Bang Province, Vietnam conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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