RESEARCH ON PRODUCTION OF BIOLOGICAL PRODUCTS OF *CHAETOMIUM* FOR CONTROLLING FUNGAL DISEASES ON TEA, COFFEE AND RUBBER

Nguyen Huu La*[1], Nguyen Van Thiep[1]

Abstract

Two strains of *Chaetomium* which were popular and with high antagonistic activity from tea, coffee and rubber soil in Northern Vietnam were identified, including *Chaetomium bostrychoides* and *Chaetomium globosum*. These strains had strongly antagonistic activity to *Fusarium* sp. causing root rot on tea, coffee and rubber and *Colletotrichum* sp. causing tea anthracnose. New identified *Chaetomium* strains were successfully used to produce biological products for controlling disease called CP2-VMNPB. The product composition was capable to exclude fungal diseases well such as *Fusarium* sp. (85.62%); *Colletotrichum* sp. (81.80%) after one month in laboratory conditions; in greenhouse conditions, the effect on root rot tea and coffee reached 83.30%, with powdery mildew disease on rubber *Oidium Hevea,* the effect reached 81.17% after 3 months.

Keywords: Tea, coffee, rubber, bio-fungicide, *Chaetomium, Fusarium, Colletotrichum theae-sinensis, Oidium heveae*

INTRODUCTION

Tea, coffee and rubber are perennial plants which survive and grow throughout the year and they are continuously damaged by many types of pestilent insect and diseases.

The control of disease on tea, coffee and rubber has mainly based on chemical methods which seem less effective and leave residues in the environment and are harmful to the health of consumer as well as producer. There have been studies and applications of beneficial microorganisms to control plant diseases, one of the microorganisms were *Chaetomium* (K. Soytong 1989). *Chaetomium* falls under the list of saprophytic fungi which have strong competitiveness against disease fungi, especially *Chaetomium globossum* and *Chaetomium bostrychoides* with strong resistance to pathogenic fungi of the *Fusarium* and *Helminthosporium* (Tveitand Moore, 1954), *Alternaria, Collectotrichum* (Vannacci *et al*., 1978; C. Talubnuc *et al*., 2010), and so on. The antagonistic activity of *Chaetomium* is due to the synthesis of antibiotic *Chaetoglobosin,* which breaks down cell membranes, making the cytopla broken and lose toxicity of fungal diseases (Di Petro, 1992; K. Soytong, 2007). In addition, *Chaetomium* helps stimulate growth and development, increase the resistance of plants (Le Thi Anh Hong, 2005; Doke *et al*., 1991).

Based on the useful characteristics of *Chaetomium*, the Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI) has carried out the research and production of *Chaetomium* compositions to eliminate diseases on tea, coffee, rubber and other crops.

MATERIALS AND METHODS

Materials

Soil samples from the tea, coffee and rubber gardens for isolating *Chaetomium*; fungal pathogens were *Fusarium* sp., *Colletotrichum theae-sinensis* and some other pathogenic fungi from sources stored at the Department of Biotechnology & Plant Protection, NOMAFSI.

Isolate antagonistic *Chaetomium;* Review of active resistant characteristics of *Chaetomium* against root rot on tea, coffee and rubber caused by *Fusarium sp*. Tea leave rot caused by *Colletotrichum camelliae* nursery (C. sinensis - theae).

Methods

- Isolation and purification of Chaetomium: The soil samples were cut into small pieces and put on the surface of a petri dish with filter paper of 1 cm^2, humidificating and moisturizing regularly at room temperature to trap fungus by the method of K. Soytong 1989. Each fungus was separated by sterilized implants and implanted onto PDA to track the generation and development of spores.

- To assess the activity of the Chaetomium against fungus disease: Perform the experiment by conducting transplants symmetry 2 antagonist fungus and pathogens on the surface of potato dextrose agar in petri dishes 9cm, transplanting in place 1cm from the edge of the petri dish:

Disc 1: Mushrooms antagonists (Chaetomium);

Disc 2: Mushrooms antagonists (Changing domain name) and fungal pathogens (NGB);

Disc 3: Pathogens (control);

[1] Northern Mountainous Agriculture & Forestry Science Institute (NOMAFSI)

* Corresponding author: nguyenhuula@gmail.com

The experiment was randomly designed with 3 replications; Keep track of the daily growth of 2 fungi (NDK and NGB) and the crowding together by measuring the diameter of fungal growth and spore counts of both NDK and NGB. The experiment followed by the method of Soytong 1989 and SeiKetov 1982; Le Anh Hong 2005. Counting spore by MCV ruler; the inhibitory effect of NDK was calculated by using the formula of PIRG (Percent Growth Inhibition of Radical) = (R1- R2) / R1 × 100. Of which: R1- the development diameter of colony or number of fungus spores in the petri dish; R2 - the development diameter of colony or number of fungal spores in the opposite dish.

- Production and evaluation of compositions: A composition comprised of cooking oil, water, sacaroze sugar, amino acids and fungal spores:

Treatment 1: Vegetable oil 50%; distilled water, sugar and fungal spores 49%; amino acid powder 1%;

Treatment 2: Vegetable oil 60%; distilled water, sugar and spores 39%; amino acid powder 1%;

Treatment 3: Vegetable oil 70%; distilled water, sugar and fungal spores 29%, amino acid powder 1%;

Treatment 4: Vegetable oil 80%; distilled water, sugar and fungal spores 19%, amino acid powder 1%; The amount entered *Chaetomium* spores reach 10^9 CFU/ml.

- Experiment to evaluate effectiveness of compositions: Planting tea, coffee and rubber of 1 year old in a pot, put in the greenhouse, when they turn in to green, spreading contagious tree root rot and powdery mildew disease. For tea and coffee, spreading root rot, *Fusarium* sp. For rubber trees, spreading the powdery mildew disease (*Oidium Hevea* up leaves). After one month of spreading disease, the composition was processed. Diluting CP2-VMNPB composition with water and watering on crops (for root rot) and spraying on foliar (for rubber powdery mildew disease) according to the dosage: Treatment 1: 0.5 ml of composition/ tree; Treatment 2: 1 ml of composition/tree; Treatment 3: 1.5 ml of composition/trees; Treatment 4: 2.0 ml of composition/trees; Treatment 5: control, spraying water.

- Survey the disease index through disease symptoms expressed on foliar as follows: level 1: healthy plants, green leaves; level 2: 1-25% with yellow leaf; level 3: 26-50% with yellow leaf; level 4: 51-75% with yellow leaf; level 5: > 75% with yellow leaf.

RESULTS AND DISCUSSION

Result of collecting and isolating *Chaetomium*

In order to have *Chaetomium* strains for producing composition, the soil samples were collected from the tea, coffee and rubber gardens in the main growing areas such as Phu Tho, Thai Nguyen, Nghe An, Son La, Lai Chau, Yen Bai. 30 g of each soil sample was made into small pieces and put into a petri dish 9cm for trapping fungi. The trapped *Chaetomium* was purified and identified scientific name in King Mongkut University, Thailand. 23 strains of *Chaetomium* have been identified, including 11 strains from tea soil, 8 strains from coffee soil and 4 strains from rubber soil. Of which, two strains of *Chaetomium bostrychoides* CPT1 were isolated from tea soil and *Chaetomium globosum* CFSL1 was isolated from coffee soil which was quite popular and vigorous. These strains were used for evaluation of antagonistic activity against fungal diseases on tea, coffee and ruber.

Antagonistic activity of Chaetomium against some fungal diseases

Two popular strains of *Chaetomium* isolated from tea and coffee soil were evaluated for antagonistic activity against oot diseases caused by *Fusarium* sp. and anthracnose caused by *Colletotrichum* sp. in petri dishes with PDA under laboratory conditions.

Table 1. Antagonistic activity of *Chaetomium* strains against *Fusarium* sp. after one month

Treatment	Fungi colony condition (cm)	Inhibitant ability (%)
Fusarium sp. (control)	9.00 a	
C. bostrychoides against *Fusarium* sp.	3.74 b	58.44 b
C. globosum against *Fusarium* sp.	3.21 c	64.33 a
CV%	*3.86*	*3.10*
$LSD_{.05}$	*0.41*	*4.30*

One month after implantation in medium: in the control dish, *Fusarium* sp. developed fully on petri dishes 9 cm and Fungi colony was quite thick. In dish with antagonistic agent, *Fusarium* sp. was inhibited by *Chaetomium* colony and thus scaled down (3.21cm) being smaller than *Chaetomium* colony (5.79 cm). Also on the surface there appeared *Chaetomium* bag (Figure 1). That was because *Chaetomium* has grown, the mycelium spread to *Fusarium* colony encroaching and inhibiting the growth of fungal disease causing

the size of fungi reduced (Soytong *et al.*, 2001). The *Chaetomium* mycelium coat on the surface of fungi disease developed and created bag on fungi disease surface.

In both *Chaetomium* strains collected, *Chaetomium globosum* (Cg) had stronger antagonist activity against *Fusarium* than *Chaetomium bostrychoides* (Cb). In disc having *Chaetomium globosum*, the size of fungi disease colony was 3.21cm and effectiveness of inhibitant activity against the development of fungi disease colony of Cg was 63.33 % Cg, while in disc having Cb the size of fungi disease colony was 3.74cm and Cb inhabits 58.44% the development of *Fusarium* sp.

For both control fungi and disease fungi, mycelium grew over time while producing spores, *Chaetomium* inhibited the growth of fiber system, and also inhibited the reproductive spores. We evaluated this activity through fungal spores number formed in the control experiment compared with the freely developed disease fungi, the results in Table 2.

Table 2. Inhibitance against the development of *Fusarium* sp. Spores of newly isolated *Chaetomium*

Treatment	No. of spores (10^7)	Inhibitant ability (%)
Fusarium sp. (control)	67.46 a	
C. bostrychoides against *Fusarium* sp.	6.20 b	90.08 b
C. globosum against *Fusarium* sp.	4.18 c	93.80 a
CV%	*8.03*	*6.24*
$LSD_{.05}$	*1.76*	*3.12*

The experiement result showed that the number of root rot spores differed as opposed to different strains of *Chaetomium*. Number of spores of *Fusarium* sp. in formula against Cg (4:18 x 10^7 spores/g) was less than the formula against Cb (6.2 x 10^7 spores). The effectiveness of inhibitation against the growth of fungal spores of Cg reached 90.08%. From the experiments in Table 1 and 2, though the *Chaetomium* strains did not strongly inhibit the development of disease fungi colonies, it had the excellent inhibition against the formation of disease fungi spores. The result had a significance on the inhibition of spreading epedimic of root rot trees caused by *Fusarium sp.*

Anthracnose damages foliar and twigs of many different crops. On the tea plants, *Colletotrichum camelliae* causes anthracnose on leaves, buds, twigs of tea plants; on coffee trees, the disease caused by *Colletotrichum* sp. Antagonistic ability of the *Chaetomium* strains was also assessed towards these two species of fungal disease. Since the experiment results were the same, therefore, only the result of study on *Colletotrichum* sp. was presented.

Table 3. Antagonistic activity of several *Chaetomium* strains against *Colletotrichum* sp. after one month

Treatment	Fungi colony condition (cm)	Inhibition ability (%)
Colletotrichum sp. (control)	9.00 a	
C. bostrychodes against *Colletotrichum* sp.	3.61 b	59.88 b
C. globosum against *Colletotrichum* sp.	3.12 c	65.33 a
CV%	*5.06*	*9.83*
$LSD_{.05}$	*0.42*	*3.24*

For *Colletotrichum* sp., Fungal antagonists also inhibited the growth reducing the disease fungi size to 3.12-3.61cm only while in fungal control formula, the disease fungi fully covered the 9cm petri disc (Figure 2). Antagonist Cg inhibited disease fungal colonies (3.12cm) stronger than the inhibition ability of Cb (3.61cm). The effectiveness of inhibition against the disease fungal growth *Colletotrichum* sp. of Cg reached 65.33% of Cg, higher than Cb reached 59.88%.

For reproductive spores of the fungus *Colletotrichum* sp. under the influence of antagonistic fungus *Chaetomium* was studied and recorded in table 4.

Table 4. Inhibition ability of newly isolated antagonistic *Chaetomium* strains against the reproductive spores of *Colletotrichum* sp.

Treatment	No. of spores (10^7)	Inhibition against the reproductive spores (%)
Colletotrichum sp. (Control)	82.64 a	
C. bostrychodes với *Colletotrichum* sp.	8.26 b	90.00 a
C. globosum với *Colletotrichum* sp.	8.15 b	90.13 a
CV%	*13.23*	*14.43*
$LSD_{.05}$	*3.35*	*6.95*

For *Colletotrichum* sp. two strains of antagonistic *Chaetomium* strongly inhibited the reproductive spores. Two strains Cg and Cb were capable of inhibiting anthracnose in the same manner (number of fungal spores in the experiment from 8.15 to 8.26 x experiment only 10^7 spores/g); the effectiveness of inhibition against the fungal reproduction of Cg and Cb were similar and relatively high (reaching 90.00 to 90.13%). From the experiments, we observed that antagonistic *Chaetomium* did not highly inhibited the growth of anthracnose colonies, but strongly restricted its reproduction of spores.

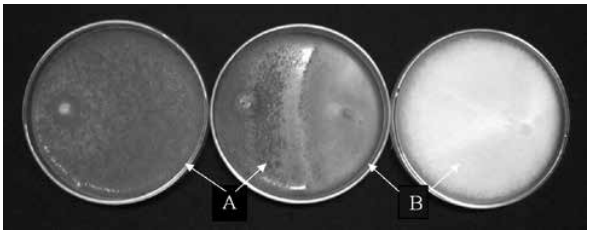

Figure 1. Antagonistic activity of *C.g* vs *Fusarium* sp.
Note: A- Chaetomium colony; B- Disease fungal colony

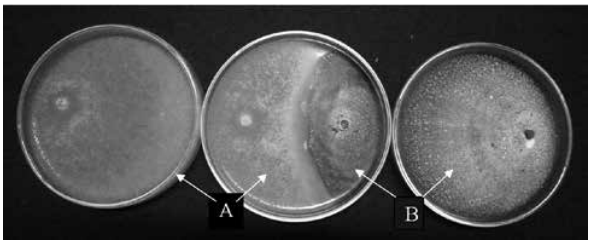

Figure 2. Antagonistic activity of *C.g.* vs *Colletotrichum* sp.
Note: A- Chaetomium colony; B- Disease fungal colony

With the goal of producing compositions capable of excluding diseases for both tea and coffee, the simultaneous use of antagonistic strains isolated from tea and coffee soil in the composition will be effective. However, two strains of antagonists Cg and Cb had strongly effective antagonist against the disease fungi causing root rot and anthracnose on tea and coffee, but when combined whether they can influence to reduce the effectiveness of each other or not. The study result of combined antagonistic activity of two strains of Cg isolated from coffee soil and Cb isolated from tea soil recognized in table 5.

Table 5. Antagonistic activity of the combination of two Chaetomium strains against the root rot and anthracnose on tea and coffee

Treatment	*Fusarium sp.*		*Colletotrichum* sp.	
	Fungal colony (cm)	No. of spores (10^7)	Fungal colony (cm)	No. of spores (10^7)
Control	9.00	7.82	9.00	7.18
Disease fungi	3.72	0.76	4.00	0.72
Inhibition effectiveness (%)	58.66	90.28	55.55	89.97

The experimental results have demonstrated the combination of two *Chaetomium* strains, the antagonistic activity against disease fungi remains strong as the individual strain. The combination of two *Chaetomium* strains inhibited the growth of fungal colony of the two diseases from 55.55 to 58.66%; inhibits the reproduction of spores from 89.97 to 90.28%. From the experiments, the *Chaetomium* strains could be combined together without having impact in inhibiting each other in the composition having *Chaetomium* strains, so the composition will have a broader effectiveness.

Study for production and evaluation of new compositions

Study on production of compositions

Based on the experiments for blending with the ratio of different components based on the four formulas as described in the method, the active ingredients were 2 strains of *C. bostrychoides* CPT1 and *C. globosum* CFSL1. The liquid composition having vegetable oil, sugar, amino acid powder, distilled water and *Chaetomium* spores was collected. After having additive to dissolve vegetable oil, the treatment 2 (including vegetable oil: 60% + distilled water, sugar and fungal spores: 39% and amino acid powder 1%) become the liquid, not being precipitated and deposited, which meets the requirement to produce compositions. Fungal spores in the composition reached at least 1.0×10^9 spores/ml.

Evaluation of effect of composition in laboratory condition

To evaluate the effect of the newly produced compositions against disease fungi, the first experiments were performed in laboratory conditions. Fungus was grown in PDA environment in petri disc 9cm and cultured in the opposite position, tracking the development of the fungal colonies after 1 month, calculated the inhibition effectiveness of the composition (PIRG) .

Table 6. Effect of compositions against *Fusarium* sp. and *Colletotrichum* sp.

Treatment	Effect to exclude fungi after one month (%)	
	***Colletotrichum* sp.**	***Fusarium sp.***
Treament 1	43.34 d	44.90 d
Treament 2	81.80 a	85.62 a
Treament 3	69.75 b	71.73 b
Treament 4	56.78 c	65.57 c
CV%	*4.55*	*4.10*
$LSD_{.05}$	*5.39*	*5.17*

In laboratory conditions, the experiment under formula 2 had the effect of excluding *Fusarium* sp. fungus and *Colletotrichum* sp. at the highest level of 85.62 % and 81.80 % . Based on the results of experiments, the effect of excluding disease fungi and uniformity of composition solution was evaluated, the treatment 2 has been used to produce composition. The new composition was named CP2 - VMNPB.

Effect of excluding disease fungi of CP2-VMNPB composition in greenhouse

The seedlings used for experiment were planted in pots, after stalilizing their roots, conducting the spread of disease, when the symptoms appearing, the composition with certain different composition concentrations was produced. The objective was to add to the evaluation of the effect of composition and determine the reasonable dosage of composition. The evaluation results of composition CP2 - VMNPB was in Table 7.

Table 7. Effect of CP2-VMNPB against the root rot on tea and coffee in greehouse condition after 3 months

Treatment	Experiment on tea		Experiment on coffee	
	Disease index (%)	Fungicides (%)	Disease index (%)	Fungicides (%)
Treament 1- 0.5ml/tree	0.13 b	79.43 c	0.14 b	78.76 b
Treament 2- 1.0ml/ tree	0.13 b	80.71 bc	0.13 b	80.58 ab
Treament 3- 1.5ml/ tree	0.12 bc	82.34 ab	0.12 c	82.84 a
Treament 4- 2.0ml/ tree	0.11 c	83.43 a	0.12 c	83.30 a
Treament 5- Not process	0.68 a		0.71 a	
CV%	*5.04*	*1.28*	*3.18*	*1.98*
$LSD_{.05}$	*0.015*	*1.96*	*0.016*	*3.04*

After the observation period, symptoms in the experimental tea were reduced. With the different dosages, disease indexes and the effect of excluding diseases were different. Statistical experiment results showed that the dose treatment with 0.5 - 1.0 ml/ pot (plants) had similar disease indicators and the effect of excluding disease was similar (from 79.43 to 80.71% for tea and from 78.76 to 80.58% for coffee); treated with doses from 1.5 - 2.0 ml/pot, the effect of excluding disease was equivalent and achieved the highest results, from 82.34% to 83.43% on tea and from 82.84 - 83.3% on coffee.

The results showed that by using of dose of 2ml CP2 - VMNPB/tree, excellent effect of excluding root rot for tea and coffee was obtained.

Rubber trees often appear many diseases, powdery mildew disease caused by the *Oidium heveae* causing deciduous, it takes long time for rubber trees to have new leaves to replace, latex yield is therefore seriously affected. Especially disease in the nursery garden causes trees grow slowly, kill slips premature, reduce the incidence of the garden. The new composition was studied with the trial exclusion of powdery mildew disease in Table 8.

Table 8. Effect of CP2-VMNPB against powdery mildew disease for rubber trees after 3 months

Treatment	Disease index (%)	Effect (%)
Treatment 1- 0.5ml/ tree	0.22 b	74.11 b
Treatment 2- 1.0ml/ tree	0.20 b	76.47 b
Treatment 3- 1.5ml/ tree	0.17 c	80.00 a
Treatment 4- 2.0ml/ tree	0.16 c	81.17 a
Treatment 5- No process	0.85 a	36.29 c
CV (%)	*7.43*	*11.34*
$LSD_{.05}$	*0.022*	*2.96*

For powdery mildew disease on rubber tree, handle compositions with different dosages had different results. At doses of 0.5 - 1.0 ml/tree, the effect of

excluding disease reached from 74.11 to 76.47 similarly; increasing the dose to 1.5ml composition, the effect was increased to 80%; increasing dose up 2.0ml/tree, the effect reached 81.17%, equivalent to the treatment dose of 1.5ml/tree. Assay on rubber powdery mildew disease had similar result to root rots on tea and coffee trees, the dose of composition from 0.5 to 1.0 ml/pot, disease index and effect of excluding disease was similar, and dose of 1.5 - 2.0 ml/tree, the effect was increased.

So, after 3 months of treatment with the dose of 1.5 and 2.0ml/pot (plants) had good effect of excluding disease for both root rot on tea and coffee and poweder mildew disease on rubber leaves, reach over 80%. However, applying 1.5ml of composition per tree for disease control will also achieve the effect from economic perspective.

CONCLUSION

Two strains of *Chaetomium* quite popular in soil planning tea, coffee and rubber in Northern Vietnam as *Chaetomium globosum* CPT1 and *Chaetomium bostrychoides* CFSL1 were identified.

New *Chaetomium* had strongly antagonistic activity with *Fusarium* sp. causing root rot tea, coffee and rubber (ability to inhibit the production of fungal spores reached 90.08 to 93.80%) and at the same time had strong resistance to *Colletotrichum* sp. causing anthracnose (90 to 90.13% inhibition of fungal spores reproduction).

CP2-VMNPB composition produced from two *Chaetomium* strains had high effect of excluding fungi, with *Fusarium* sp. Reached 85.62% and *Colletotrichum* sp. reached 81.80% after one month in laboratory conditions, in greenhouse conditions, the effect on root rot tea and coffee reached 83.43% and 83.30%, with powdery mildew disease on rubber *Oidium Hevea,* the effect reached 81.17%.

REFERENCES

Le Thi Anh Hong, 2005. Chaetomium fungi applied research in the production of biological products and plant protection fungal disease prevention; *Scientific and Technical Review Report*, the Agricultural Genetics Institute, MARD (in Vietnammese).

Nguyen Van Vien, Nguyen Thi Tu, Bui Van Cong, 2012. Research production and use of Trichoderma viride prevent fungal diseases root zone, potatoes, peanuts, soybeans. *Journal of Science and Development* in 2012: Volume 10, No. 1: 95-102, HAU (in Vietnamese).

Di Petro, 1992. Role of antibiotics produced by in biocontrol of *Pythium ultimum*, a causal agent of damping off. *Phytopathology* 1992, 82 p. 131-135.

Doke N. , Y. Miura, H.B. Chai and K. Kawakita, 1991. Involement of action oxygens induction of plant defense response against infection and injury. In: active oxygen/oxidative stressand plant metabolism (eds E.J. Pell and K.L teffen). *American Society of plant Physiology*, Rockville, MD:84-96.

Soytong K. , 2007. *Disease Management for Biological Agriculture.* Faculty of Agricultural Technology, KMITL, BKK, Thailand.

Soytong K., 1989. Antagonism of *Chaetomim cupreum* to *Pyrialaria oryzae*: a case study to biocontrol of a rice blast disease. *Thai Phytophathology* 9: 28-33.

Talubnuc C., K. Soytong, 2010. Biocontrol of vanina anthracnose using Emericella nidulans. J. *of Agricultural technology* 2010, vol 6 (1): 47-55

Tevit M., M.B. Moore, 1954. Isolate of Chaetomium that protect oats from Heminthosporium victoriae. *Phytopathology* 44, p.686-689.

Vannacci G., G.E. Harman, 1978. Biocontrol of seedborn Alternaria raphani and A. brassicicola. *Can. J. Microbiol.* 33, p. 850-856.

Date received: 25/10/2016
Date reviewed: 20/11/2016
Reviewer: Dr. Truong Hong
Date approved for publication: 20/12/2016

EFFECT OF STORAGE TEMPERATURE AND LOW TEMPERATURE CONDITIONING ON QUALITY AND CHILLING INJURY OF 'LD1' RED FLESH DRAGON FRUIT

Nguyen Van Phong*[1], A.B. Woolf[2]

Abstract

Vietnam is a significant producer of dragon fruit, mainly concentrated on white flesh cultivars up to now. 'LD1' characterized by red flesh was newly bred cultivar and has been widely cultivated in Vietnam but limited research on postharvest was reported. In this study, we examined the effect of storage temperature (2, 6 and 10°C) for 2 or 4 6 weeks on quality of LD1 fruit in comparison with the control (non-stored - 20°C). In addition, the potential for improving quality by using low temperature conditionings (LTC) at 6 and 10°C for 3 days before keeping fruits for storage at 2°C. For fruit that were not cool stored (kept at 20°C), fruit could be kept for approximately 5 days, but quality decreased rapidly so that by 9 days fruit began to rot. For cool stored fruit, 6°C was the best temperature resulting in a good quality for up to 4 weeks without chilling injury. At the lowest storage temperature (2°C), fruit suffered chilling injury which included wilting and desiccation of the bracts, and translucence of the outer flesh with low percentage of fruit rotten was observed. Chilling symptoms were appeared after even 2 weeks of storage and increasing with storage duration. Chilling symptoms and rot incidence increased dramatically with time at 20°C after removal from storage. Low temperature conditioning slightly reduced chilling symptoms at 2°C. These results provide initial recommendations for postharvest storage conditions, and directions for further research.

Keywords: *Hylocereus undatus,* postharvest, temperature, chilling injury, disease

INTRODUCTION

Dragon fruit (*Hylocereus undatus*) is an exotic fruit, belongs to the *Cactaceae* family and originated from tropical forest regions of Mexico and Central and South America (Mizrahi *et al*., 1997). In Vietnam, dragon fruit have been grown for over 100 years since introduction by the French. However, the commercial production has not significantly been developed until 1980's with mainly white-flesh cultivar - Binh Thuan (Luders and Mc Mahon, 2006), this being named after the main growing region in Vietnam.

While white-flesh cultivars ('Binh Thuan' or 'Cho Gao') are still the main ones for export, newly bred cultivars with coloured flesh are receiving increased interest due to both novelty and that the red pigments are perceived as a potential health benefit. 'LD1' is a hybrid 'Binh Thuan' and a red flesh Colombian cultivar, which was developed by SOFRI and released in 2005. It has desirable agronomic characteristics and is similar to 'Binh Thuan' in terms of fruit quality, fruit weight and shape, but has a softer texture.

However, the postharvest characteristics of 'LD1' are poorly understood and almost no studies relating to the optimum storage temperature was found. Storage temperature is the most important postharvest factor, and is dependent on variety and environmental conditions. In Israel, the best storage temperature for dragon fruit is 10°C (Nerd *et al*., 1999), whereas 5°C was recommended in California Freitas & Mitcham (2013) and in Vietnam for 'Binh Thuan' (To *et al*., 2002).

Along with storage temperature, low temperature conditioning treatment (LTC) is a possible tool to reduce chilling injury. In avocado, Woolf *et al.* (2002) reported that LTC at 6 - 8°C for 3 - 5 d could reduce external chilling injury during storage at 0°C. Similarly in using LCT on papaya, fruit is held at 12.5°C for 4 d, before storage at 2°C (Chen & Paull, 1986).

Thus, this work is aimed to determine the effect of storage temperature on overall fruit quality and chilling injury in a new dragon fruit selection (LD1), and the impact of low temperature conditioning (LTC).

MATERIALS AND METHODS

Fruit and packaging

Dragon fruit - red flesh fruit cultivar named. LD1 was harvested at a mature stage with full red skin (about 28 - 30 days after flowering) from a commercial production farm at SOFRI in the early rainy season (May, 2013). After harvest, fruits were transported immediately to the laboratory where they were graded, excess stem trimmed and hand-washed then air-dried under fans.

Fruit were stored individually in 25μm perforated polypropylene bags without sealing (4 × 5 mm

[1] Southern Horticultural Research Institute (SOFRI), Tien Giang, Vietnam
[2] The New Zealand Institute for Plant & Food Research Limited (PFR), Auckland, NZ
* Corresponding author: phongsofri@gmail.com