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THE INTRODUCTION OF GAP AND QUALITY SYSTEM FOR PITAYA IN VIETNAM

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ABSTRACT

*In Vietnam, at present, the area for dragon fruit (DF-pitaya) is about 45,450 ha with a total production of 587,968 tons and the average DF area per household is 0.5- 1 ha. Unfortunately, producers of DF have seen prices of fruits decline since the product mainly are sold to local consumption or neighboring countries. Recent concern over food safety, returns from pitaya could be significantly improved if small growers and exporters can gain access to new high value markets in Europe and North America. This could be done if Good Agricultural Practice (GAP) programs are in place. The development of safe horticultural models and implementation of GAP (GLOBALGAP, VietGAP) are becoming exaggerated together with its importance in the food supply chain. VietGAP was issued by the Ministry of Agriculture and Rural Development (MARD) in 2008 and has become a priority and a compulsory regulation in fruits producing and market. To develop GAP, many topics need to be covered: (i) Field farmers' benchmarking survey; (ii) Selection of a packer/exporter and farmer group for the Pilot; (iii) Development of the pitaya quality manuals for the farmers; (iv) The national personnel capacity building has seen practical GAP proficiency developed; there were three main production areas for pitaya in the Provinces of Binhthuan of about 24,191 ha with 430,120 tons, Tiengiang of 4,052 ha with 75,109 tons and Longan of 5,568 ha with 78,500 tons in 2016. By the year 2017, 10,083.5 ha had been certified for GlobalGAP/VietGAP. Of them, 9,700 ha from Binhthuan, 310 ha from Longan and 73.5 ha in Tiengiang province. In Vietnam, the quality systems for DF are formed from the central to local levels to manage production and distribution. MARD directs and gives policies to support the locals in producing DF under GAP standards, applying IPM on DF production in order to reduce the use of pesticides and inorganic fertilizers, together with the increasing use of organic manure. The crop is affected by a number of pests and diseases with diseases causing the greatest losses both in the field and postharvest. The major field diseases in Vietnam are canker (*Neoscytalidium dimidiatum*), bacterial soft rot (*Erwinia chrysanthemi*), anthracnose (*Colletotrichum gloeosporioides*, *C. truncatum*). In this paper, more related things have been discussed.*

Keywords: GlobalGAP, VietGAP, SOFRI, PFR, IPM, Dragon Fruit (DF), Pitaya, manual, *Neoscytalidium dimidiatum*, *Colletotrichum gloeosporioides*, *C. truncatum*

INTRODUCTION

Dragon fruit in Vietnam is considered one of the important agricultural products which is preferred by both the domestic and international consumers. The area of DF has rapidly increased in the last decade. It was only 560 ha in 2000, and increased up to nearly thousands of hectares in 2005 and 18,000 ha in 2010, later area and

production of Vietnam's DF were expected to reach at 28,500 ha and 585,000 tons, respectively. The weather conditions in the Southern part of Vietnam is favorable for DF production. There are more than 30 provinces producing DF throughout the country, especially, Binh Thuan, Tien Giang and Long An which are mainly considered as the top producers of DF in the country. In 2013, Binh Thuan province has the largest area of 20,000 ha (77% percent of total area of DF in whole country), Tien Giang province at 3,000 ha (11.5 %) and Long An province at 2,100 ha (8%). At present, the area for DF is about 45,449ha with the production of about 587,968tons and the average area per household is 0.5 – 1 ha (MARD, 2017). Producers of DF have seen prices for their fruit decline by about 60% since 2000 since the product are mainly sold for local consumption or to neighboring countries. Returns from DF could be significantly improved if small growers and exporters can gain access to new high value markets in Europe and North America. However, the Vietnamese exporters will need to find alternative markets for their products. High-value markets in Japan, Europe and North America have been non-receptive to Vietnamese DF due to perceptions of poor quality and lack of legal and food safety accountability. Different projects were aimed at developing quality systems for export market access for DF. The projects have established a private sector working pilot of exporter/packer and supplying DF growers in which the European high value market driven standards of BRC at the packer and EUREPGAP/GlobalGAP/VietGAP at the farmer level. These were carried out with following main objectives: (i) To increase small holders' competitiveness and capacity to supply DF to high-value international markets, introducing new concepts of food safety, environmental responsibility, sustainability and worker safety into their production practices; (ii) To provide technical support and training for Vietnamese extension workers/researchers to improve their capacity in group training procedures for GAP implementation in DF; (iii) To improve the quality systems for DF from the central to local levels, from farmers to packers, exporters and consumers to manage production and distribution.

METHODOLOGY

The overall approach to project dissemination within the projects is reliant on the major assumption "that returns for each stakeholder from high value export markets using GAP are far greater than the returns generated during the pre-GAP status". High returns from GAP DF production, packing and export will ensure growth and sustainability in the DF industry. The growth will also ensure increasing numbers of small-holder DF growers that have accessed to participation in the programme and improved living standards.

It is intended that the development of the Vietnamese personnel, both in the public and private sectors, will be through the practical application of:

- Establishment of the current status of the DF industry against GAP standards through a benchmarking survey. The field observation for the farmers' benchmarking survey both at Binh Thuan and Tien Giang – Long An was carrying out as the standards method for GAP benchmarking. The survey form has been developed and the result was analyzed by HortResearch and SOFRI scientists;
- Improvement of the current understanding of DF agronomy within SOFRI and establishment of the systems for constant improvement and problem solving;
- Development of pilot models of GAP-compliant farmer groups in the field and the packhouse pilot model of BRC – complinat for Exporter/Packer. The market driven quality standards are complex and must be continuously maintained and improved, often beyond the capability of the small-holder farmer, so the group of farmers need to be formed and function effectively. With the establishment of the quality system responsibilities in the packhouse compliance issues, training and support can be provided to the farmers by SOFRI team;
- Production of manuals, Codes of Practice and the development of training materials that is appropriate, user friendly, developed by the Vietnamese extensionists, and are appropriate to the DF industry for transfer to subsequent "models" and ultimately, other crops;
- Establishment of required quality systems for the DF industry to adopt and obtain proof of the system robustness, by obtaining GAP certification for the pilot model;
- Maximization of the impact of current initiatives to develop GAP in the DF industry through full participation in the DF GAP Projects; and
- Capacity building for further GAP implementation on other crops in Vietnam.

RESULTS AND DISCUSSION

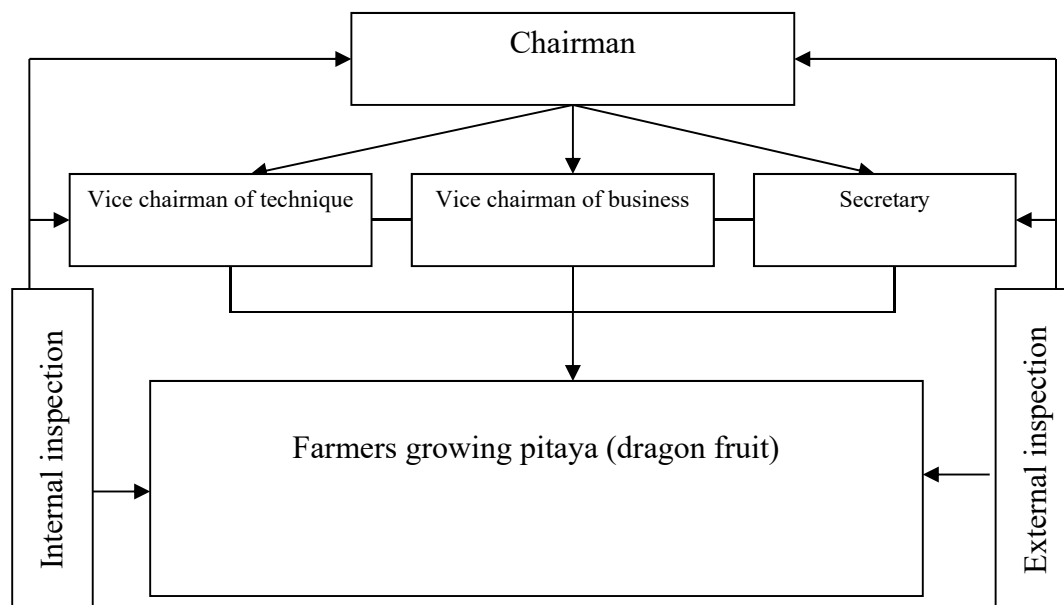
Quality systems for DF in Vietnam

DF production distributed to domestic consumption and export markets. DF of Vietnam has been presented to 40 countries and territories all over the world. China is the biggest export market of Vietnam's DF (Lap *et al.*,

2013). In Vietnam, the quality systems for DF are formed from the central to local levels to manage production and distribution. MARD directs and gives policies to support the locals in producing DF under Good Agricultural Practices (GAP) standards including VietGAP and GlobalGAP, applying IPM in DF production in order to reduce pesticides and use of inorganic fertilizer, as well as increasing the use of organic fertilizers.

At the growing areas of DF each province is supported by the Department of Agriculture and Rural Development (DARD), which has specialized part to manage the quality of agricultural products including DF. DARD and local governments implement the planning for growing DF, building models of farmers' organizations such as cooperatives or group farmers to link farmers cultivating DF with small areas into groups of farmers who are growing DF under the same certain standards such as GlobalGAP or VietGAP. Each group of farmers (cooperative groups or cooperatives) is made up of about 30-100 households linked together to plant DF under VietGAP or GlobalGAP standards (Chart 1). The Management Board of VietGAP at DF cooperative group operates the quality system to ensure the production process of the DF farmers to follow the rules of VietGAP. The DF growers function voluntarily to do agreement with the management of the cooperative groups in the implementation of the VietGAP standards. Cooperative group represents households to be legal with VietGAP certification organization. The DF businesses are linked to farmers' organizations (cooperatives or cooperative) to buy DF. The DF packing facilities are also encouraged to follow safety procedures under GAP in the stages of purchasing, grading, packaging, storage and transport to the market (Fig. 1).

Fig. 1. Planting Pitaya under VietGAP standard at cooperative group



About managing pests on the DF, the MARD directs the units under the MARD including SOFRI to study the measures, promulgate management processes of pests on DF and guide the local to apply them. MARD promulgates the list of pesticides which are permitted in Vietnam and expressed through circular No. 06/2017/TT-BNN dated 08/3/2017. DF has 41 trade names. Encourage the use of non-chemical measures on DF like field sanitation, antagonistic fungus, ..., apply fruit bags to prevent fruit flies and worms. The Plant Protection Department (PPD) coordinates with functional units to organize the inspection, checking for the produce and selling pesticides on certain conditions like trade in drugs, labelling, standard drug, duration of use, etc. Regarding the standard production and codes of plantations, PPD is a unit under the MARD that manages growing areas of DF reaching export standards through monitoring systems and grant code for exporting DF. By the end of 2017, Vietnam had planted 3,679 ha of dragon fruit issuing the exported code to Korea, Japan, Taiwan, US, New Zealand, and Chile. There are code-growing areas for the cultivated area under VietGAP or GlobalGAP that comply with the regulations on the use of pesticides for the importing country.

The Horticultural Institutes, the universities, the research centers conduct studies and transfer research results on DF to the stages of the DF supply chain in breeding, cultivation, plant protection, harvesting and

maintenance postharvest and product marketing. SOFRI is the research agency playing an important contribution in the breeding of new varieties, planting process, caring and handling of flowers, plant protection, harvesting and preserving DF.

Benchmarking

The field portion of the benchmarking survey was completed by the SOFRI team in late July, 2005 (Hoa *et al.*, 2010). Some 124 farmers from Binh Thuan and 30 farmers from the Tien Giang province were interviewed and 110 framers from Longan province in 2010 (Hoa *et al.*, 2015). The SOFRI team recorded farmer information for the formal EUREPGAP/GLOBALGAP/VietGAP oriented questionnaire and also recorded additional current agronomic and technical information related to the surveyed farmers DF production practices.

The first benchmarking survey data were analyzed at HortResearch (now PFR) the staff of whom also prepared a PowerPoint presentation for delivery. Other survey data were analyzed by SOFRI for GlobalGAP/VietGAP surveys (Hoa *et al.*, 2010). The presentations have subsequently been used as a training tool for the farmers and packers of the area. During the PowerPoint presentations, care was taken to emphasize the standards observed in the survey and to relate those conditions to the standards required to meet the high value customer-driven demands. The PowerPoint presentation and other information contained in the benchmarking survey database are being used by the SOFRI scientists during their research work.

GAP Manual Development

The DF Quality Manual has been completed in English and translated into Vietnamese (Hoa *et al.*, 2010). The manual has been developed specifically to meet the needs of the quality systems of the projects' pilot. The manual has been developed at the farmer level to the EUREPGAP Standards and later GLOBALGAP/VieGAP and in the packhouse to the BRC Standard and apart from being a living document, has been completed in its final form. Future use and adaptation of the manual to other DF packhouse/farmer group (and other crops) will have the advantage of a manual that is the actual documented quality systems of a working model. So far, SOFRI kept continue to develop manuals on GLOALGAP and VietGAP for DF and other fruit and vegetable crops. Full verification of the appropriateness of the DF Quality Manual to address the specific standards of BRC and EUREPGAP/GLOBALGAP/VietGAP and the requirements of the customer, the pilot packer and farmers have been confirmed by the Independent Certifying Bodies. Compliance assessment by the Certifying Body was planned to take place during the projects' running and is now being implemented for the pilot packhouse and model farms to comply with the standards. The knowledge gathered from DF are used by the SOFRI staff in developing manuals for many other fruit and vegetable crops.

Establish pilot GAP programme for dragon fruit in different areas

Choice of quality system standards:

At beginning, the first project chose the existing BRC and EUREPGAP quality standards as the most suitable to meet the demands of the target customer while protecting the interests of the Vietnamese stakeholders. At the farmer level the EUREPGAP Standards are being applied and at the packhouse the BRC Standards are implemented. Both standards complement each other to ensure the DF produced and packed is confirmed as safe, legal and of the quality expected by the high value market customers. The choice of the two standards has been determined by the one to high value markets identified in the project document. The project is very "customer driven" and the quality system will meet all the customer's requirements when fully implemented and will specifically provide documented proof of compliance for safe, legal quality control and traceability for the entire product during the production and packing processes. The quality systems developed will easily respond to any additional requirements from specific customers. The quality checking and documentation systems being employed in the pilot can also protect the farmer and packer from claims for damage to product (non-compliance issues) subsequent to the product leaving the packhouse. The projects had established the group of farmers and provided training in quality systems that would benefit from adopting GAP. The project has come more focused and addresses the specific needs of the farmers of the pilot to enable them to meet compliance with the standards before the proposed assessment visit by the Certifying Body.

Later projects for development of GlobalGAP and VietGAP on DF

During 2009-2012, we kept continue to consult farmers to implement activities on their farms and pack house with GlobalGAP standards at Binhthuan province (Hoang Hau limited DF company and its suppliers) and starting the same way with farmers and packer at Longan province (Duong Xuan Hoi cooperative and Huang Phat limited DF company as a packer). At Tiengiang province, we helped to conduct VietGAP standards on DF

farms and packer. Meanwhile, we helped technicians in Binhthuan province to consult more farmers to apply VietGAP on their farms and cooperatives.

Review compliance

The project team negotiated with Société Générale de Surveillance (SGS Vietnam), (in Vietnam, Regional Indonesia and New Zealand) an International Certifying agency, to provide an estimate for certification evaluation of the project initiatives. Internal reviews of the pilot have been undertaken in the form of BRC/EUREPGAP Internal Audits. The data collected has been used to determine the compliance status of the project pilot development and to initiate/tailor corrective action and training. It is intended that the learning process of the pilot development will be adapted for subsequent training during the outreach programme. Later, the DF farmers and cooperatives have been audited by international auditor company CAFFECONTROL for GlobalGAP and other cooperatives by national auditor companies - FFC for VietGAP certifications (Table 1).

Table 1. Pitaya producing and GAP's certificated area
(South Horticultural Research Institute, 2018)

No.	Province	Cultivated area (ha)	GAP certificated area (ha)	Note
1	Binh Thuan	27,031	9700	VietGAP + GlobalGAP
2	Long An	7,552	310	VietGAP + GlobalGAP
3	Tien Giang	5,042	73.5	VietGAP + GlobalGAP
	Total	39,625	10,083.5	VietGAP + GlobalGAP

Source from DARD of related provinces, 2017

Capacity building

Capability building of Vietnamese project collaborators has again advanced dramatically over the projecting period. It shows that SOFRI's environment is encouraging its staff to adopt the GAP initiative. The Vietnamese projects' team has an excellent understanding of GAP, and are showing confidence in delivering the project training to farmers and the packer. A formal Introductory Internal Auditor Course was presented to eight appropriate SOFRI staff by the project leader and Mr Nguyen Huu Hoang. The New Zealand Organisation for Quality (NZOQ) gave official approval for the project leader John Campbell to use a percentage of the same course material as that used during Internal Auditor training in New Zealand. This is the same material as the two day course that Mr Hoang attended during his New Zealand study tour in June 2006. Due to the requirement of NZOQ to only use a portion of their course material the SOFRI training, the whole training was done over one day and was called an "Introduction to Internal Auditing". The Internal Auditor training has been continued and its principles incorporated into much of the training programmes.

The horticultural Good Agriculture Practice initiative in Vietnam has gathered momentum during the life of this project. It is important to note that the DF project pilot is the only working model for Good Agricultural Practices in fruit in Vietnam. The SOFRI national capability, the quality manual developed for the pilot and the pilot working model are available to be used for further expansion of GAP into the DF industry and across other crops. The project and project trained personnel are making a major contribution to this initiative in a positive and quality approach. For example:

- HortResearch and SOFRI project trained personnel have an understanding of the customer driven concept which, accompanied with their quality practitioner skills, can apply the GAP technology at any appropriate level of:
 - VietGAP at the local market level and some international markets;
 - EUREPGAP plus BRC at the high value market level of the United Kingdom and Europe; and
 - Specific elevated standards GlobalGAP to enable elite markets to be accessed (through special packaging; market access protocols – disinfestation for the Japan, North America, South Pacific markets)
- The project DF Quality Manual has been prepared in a form so that it can be easily adapted to the different quality standard levels and also applied when installing quality systems to the selected standards across other crops;
- Material generated by the project for training stakeholders is relevant for many other applications in horticulture in Vietnam;

- A measurement of the capability built within the project team at SOFRI over the life of the project is clearly demonstrated by the respect of colleagues and management and the responsibilities assumed which have included;
- Dr. Nguyen Minh Chau, Dr. Nguyen Van Hoa, Mr. Vo Huu Thoai and Mr. Nguyen Huu Hoang have great contributed to the VietGAP general regulation draft, which has been delivered on January 28th, 2008 by the MARD;
- Dr. Hoa involved in a MARD funded national project developing GLOBALGAP systems in mango at SOHAFARM in the Mekong Delta, and the pilot at SOHAFARM are being audited on 30 June, 2008 for GLOBALGAP certification;
- Dr. Hoa and Mr. Hieu developed GlobalGAP systems for DF in Longan province for GLOBALGAP certification in 2012 and also kept continue to consult to farmers/cooperatives in Binhthuan to get recertification and enlarge area later;
- Mr. Hoang involved in a MARD funded national project developing GAP systems in DF in the Mekong Delta;
- Mr. Hoang travelled to Cuba as a consultant to evaluate horticulture;
- Mr. Hoang accompanied Dr Chau and others to Malaysia to attend an International Tropical Fruit Networks (TFNet) conference – Market and Marketing of Tropical and Sub-Tropical Fruit 16-18 July 2007;
- Dr. Hoa and Mr Hoang attended a workshop: Increasing Quality of Vegetable and Fruit (BRC Standard) for EU export: Held by VinaFruit and sippo (Swiss Import Promotion Programme) held at SOFRI. Workshop material has been subsequently used during training;
- The project team participated in the SOFRI DF clinic in the Tiengiang Province on 23 August 2007 and later;
- Dr. Hoa has prepared the speech to tell the experience in building GAP system in fruit in the South to present at Workshop for Tomato CARD Project and Mr. Hoang has delivered at La Thanh Hotel, Hanoi, Vietnam;
- Dr. Hoa also required to present experience in building GAP system in fruit for audient at Cantho University on September 23, 2007 and to many Provincial DARDs;
- Dr. Hoa, Mr. Campbell, Mr. Hoang and Dr. Chau, presented paper: “Development and implementation of GAP on pitaya in Vietnam: status and challenges” in 2015;
- Dr. Hoa and his colleagues were invited to present a paper on “Emerging infection diseases and insects on DF, passion fruit and longan” on the Workshop on Increasing production and Market Access for tropical fruit in Southeast Asia held at SOFRI, October 13-17, 2017;
- Dr. Hoa, Mr. Hieu, Mrs. Uyen and Dr. Quang had presented the paper: “The experiences in the development of GAP standards on fruit and vegetable crops for group of farmers, cooperatives in Vietnamese conditions and using plant clinics as tools for transfer new technologies for small-scale farmers”. on the FFTC-PCAARRD training – workshop on developing knowledge management (KM) in Agriculture for small –scale farmer held at Los Banos, Laguna, Philippines from May 8 – 12, 2017; and
- At present, there are more than 30 staff which have been trained and doing consultancies for GlobalGAP and VietGAP for DF and other horticultural crops in Southern Vietnam and they are doing research work and implementing forward organic certification on DF.

Dragon fruit diseases and their management using safe way

Stem canker disease (*Neoscytalidium dimidiatum* (Penz.) Crous & Slippers)

This disease on DF tree has been recorded in Israel since 2009 under the name of internal black rot (Ezra *et al.*, 2013); in Taiwan during 2009-2010 under the name of stem canker (Chuang *et al.*, 2012); in China, the disease was first recorded at Conghua and Yunfu towns with the name of brown spot (Lan *et al.*, 2012); and in Malaysia, Mohd *et al.*, 2013 reported that stem canker has occurred in 10 states during 2008-2009.

In Vietnam, the disease was first recognized in Binhthuan in the year 2011, but massive spread of the disease occurred. Recently, stem canker disease is the most devastating disease of DF in Vietnam (Binhthuan, Longan and Tiengiang) with approximately about 9,000 ha (20-25% of total area) were infested by canker, with yield losses ranging from 20-50% and especially growers who could not harvest the fruit during continuous rainy days or tropical low pressures. Heavily infected fruits are not marketable even in the domestic markets. By the time, the disease has reached a high level of severity, it already becomes a major threat to DF production in Vietnam (Hieu and Hoa, 2015). However, so far the disease is not clear by farmers and scientists, as well as appropriate management measures; the fruit growers are adviced to apply more fungicides as the main key to solve the problem. Unfortunately, more than 30 fungicides were carried out by SOFRI for checking disease but are still considered as unsuccessful to this day.

Symptoms of the disease: Stem canker (*N. dimidiatum*) is known as “white spot”, “brown spot” disease which attacked severely at different stages of plant and caused serious problem in reducing yield from year of 2011. Initial symptoms are appears by many small circular of pin prick on surface of cladodes or fruits, later they turn to white spot, yellowish/reddish brown canker. Finally, the spots may coalesce to cover large areas of cladode and infection may cause rot under favour conditions.

Causal agent: The fungus *N. dimidiatum* (Penz.) Crous & Slippers. has been proved to be the causal organism by both morphology and molecular detection. This fungus has been reported in Taiwan (Chuang *et al.*, 2012), China (Lan *et al.*, 2012), Israel (Ezra *et al.*, 2013) and Malaysia (Mohd *et al.*, 2013). Hieu *et al.* (2013) reported that they have isolated 80 diseased samples from Binhthuan, Longan and Tiengiang, all morphological characters were same as *Neoscytalidium*. Latelyit was confirmed by molecular DNA sequences of 233bp that 100% homologized to the *N. dimidiatum* from NCBI and then the causal organism has been proven by Koch’s postulates (Hieu *et al.*, 2014a).

Disease management: This is a new emerged disease, which was quickly spread and has a complex set of characteristics, therefore the single option could not be effective to control this complicated disease. The IDM option should be strictly followed in large scale.

+ **Field sanitation:** This is an important controlling tool which relatively has an effect to the success of the control measure; (i) as soon as the disease is noticed, all infected parts of the plant must be pruned and destroyed or chopped to small pieces for faster decomposition using EM, limes; (ii) heavy pruned after each harvesting time, include the ineffective, diseased branches and followed by preventing spray with copper fungicide; (iii) cleaning all related tools such as orchard equipment, cloths.

+ **Cultural practices:** (i) during the rainy season, all the new shoots should be removed to avoid spread of the inoculum; (ii) apply enough NPK, other macro, micro nutrients and organic manure plus *Trichoderma*, try to avoid of excess nitrogen used; (iii) grass cleaned and good orchard drainage during wet season; (iv) avoid using of unclean water for canopy irrigation since it may help in the dispersion of the inoculum; (v) Check for soil and water pH in orchards, provide limes when it needs to increase pH level; (vi) avoid over flowering manipulation during rainy season; (vii) continue to prune the newly diseased branches.

+ **Healthy seedlings:** (i) use of healthy seedlings without any symptoms from the prestigious nurseries and from healthy orchards; (ii) before bringing seedlings to the field, keep them in isolated area for 3 to 5 days for any symptom observation.

+ **Chemical use:** The disease mainly occur in the rainy season with wet weather conditions and the fungus are attached mostly on young and tender shoots, flower buds, so the spray schedule should be well arranged; (i) Prune the plant heavily after each harvest time, especially in the branches under the canopy and then spray with copper fungicide for prevention of the disease. The cover spray should be applied and focused inside the canopy branches; as soon as the disease appears (white tiny spots), the spray with either Mancozeb, Carbendazim + Hexaconazole, Difenconazole + Propiconazole at 7-10 days interval (Hieu *et al.*, 2014b). It can be combined with the wetting agent such as siloxane alkoxyolate, latex polymer blend or siloxanepoly alkyleneoxide.

Anthracnose disease (*Colletotrichum gloeosporioides*, *C. truncatum*)

Anthracnose disease becomes more and more serious and continues to damage the DF, it shows different symptoms on cladodes and fruit. It causes reduction of tree growth, yield and quality of fruit. The *Colletotrichum* spp. (Hoa *et al.*, 2011) infected on DF and caused much damage to many areas growing DF in the world. In Malaysia, this is the most popular cause of fruit damage and affects the overall fruit quality. According to Guo *et al.*, 2013, anthracnose in China was detected due to *C. truncatum*. There were at least two species of *Colletotrichum* on DF, they are *C. gloeosporioides* and *C. truncatum*. In Thailand, this was also caused by these two *C. gloeosporioides* and *C. truncatum* (Athipunyakom and Likhitekaraj, 2010; Athipunyakom *et al.*, 2012). Iskandar (2015) identified *C. truncatum* on DF in Malaysia based on morphology, color of spore, the sequencing detection too. Under field conditions, the symptoms can be used for detection of anthracnose (Hieu *et al.*, 2011). The *C. truncatum* was detected by morphological and molecular characters (Uyen *et al.*, 2018 – in press)

Symptoms

Symptoms appear on many parts of the plant including roots, cladode, branches, flowers, buds and fruit at both pre and postharvest stages.

- On root: fungus attached root above soil surface, infected part become brown and black spots.

- On cladode and branch: small yellow spot on the surface and become brown, lesions link to each other and become brown – black spot with large number concentric rings of spores. According to Sutton (1980), Swart (1999) the symptom as yellow to yellow brown, water soaking and the yellow halo was due to *C. gloeosporioides*.

- On flower: it attacks at the budding stage of flower with large numbers of concentric rings of black spores, it expands and rot laterally.

- On fruit: the spot become round or oval on fruit surface with red brown at center, it becomes dark brown spot lower than normal surface, many spots linked to each other spots become bigger, and also show concentric rings of black spores.

The lesion link to each other become bigger with different sharp. Iskandar *et al*, (2015) and Athipunyakom *et al*, (2012) described that *C. truncatum* caused anthracnose on DF in Malaysia and Thailand are the same as above mentioned. In addition, Sutton (1980) also described it the same as *C. truncatum*.

Our PCR result using ITS1 and ITS4 primers showed that the 28S rDNA sequence of 500 bp band and when made comparison with sequence from NCBI, it was 100% matching with *C. truncatum* sequence (Uyen *et al.*, 2014 – in press).

Causal agent: It caused by *Colletotrichum gloeosporioides*(Penz.) Penz. & Sacc. and *C. truncatum*.

Disease development conditions

The suitable temperature for *Colletotrichum* spp. development ranges from 23 to 35°C; pH at 5–7. Disease always develops well under wet conditions, high humidity especially during the rainy season. The spore spread through rain flash, wind and insects moving. The inocula present on plant, plant let, fruit of DF and many other hosts including grasses.

Disease management:

Reduce the inoculum in the soil

Increase number of antagonist fungi, bacteria, event *Streptomyces* spp., which help to reduce the population of pathogen and increase the activities of new roots. The organic manure decomposed from plantlet and other describes become important for plant to grow better and become tolerant to diseased infection.

Reduce to source of inoculum to orchard: After harvesting, all the plant debris should be collected whether burned or are decomposed to increase organic manure for plant to develop. So the inoculum will be destroyed.

Good water management for the orchard: High moisture in the orchards is very suitable for disease development, so keep the moisture enough for root development.

Increasing the use of organic manure on orchard: Apply enough fertilizers for plant to enhance its tolerance to the disease, especially since the use of organic manure has been found to help the control of disease infection. Use of *Trichoderma*, *Bacillus polymyxa*, *Bacillus subtilis* and *Pseudomonas fluorescens* has been proven for faster decomposition of organic matter for plant to use.

Cultural techniques: Choose seedlings from plant sources without disease. Use suitable density of plantlets per area. Apply enough, suitable fertilizers at each stage of the tree, prune for ventilation and allow sunlight to come for branch development. use more organic matters for plant. Other things are mentioned on 3.7.1.

Biological tools: Use more antagonist and beneficial fungi, bacteria (*Trichoderma*, *Bacillus*, *Streptomyces*...) to reduce inoculum and enhance the development of plant. Apply Salicylic acid for plant at 15 days before harvesting to enhance the tolerance of plant to diseases.

Using white clear and clean nylon bags for bagging fruits at 14 -15 days before harvesting day showed good option for both canker and anthracnose diseases management.

Chemical use: Apply copper fungicide for DF after fruit setting stage, when it appears, the chemicals should be applied especially those chemicals belonging to Difenoconazole, Difenoconazole plus azoxystrobin, Propineb at 7-14days interval, but it should be stopped using Difenoconazole, Axoxystrobin + Difenoconazole, Propiconazole + Difenoconazole, Propineb, Mancozeb at least 14 days before harvest., the plant extract of *Impatiens balsamina* has been proven to reduce disease development on field conditions.

Fruit soft rot (*Erwinia chrysanthemi* and *Rhizopus* sp.)

Fruit soft rot on DF is one on the major constraints, which caused serious yield lost. It first occurred in the plantation of about few years ago, the disease occurs all-year round both at orchard establishment period and commercial stage. The disease becomes dominant and more serious within the past 3-4 years; the yield lost increased from 5-20%, event thought up to 70-80% when the orchards have not been managed well. The red flesh DF is more sensitive to the disease (30-50%) than the white flesh one (<10%).

Symptoms of the disease: The disease appears on the young bud of the flower and at flowering stage (2-3 days after flower open) and the young fruit stage. At the early stage of the infection, the initial symptom appears as blister water soak and tiny bubbles on young fruit skin. By visible inspection, there are abundant of black mycelium laying on surface of lesion known as secondary infection (*Rhizopus* sp.). Infection bud or fruit

shall be complete rot soon after few hours and produce bad smell and attract wound insects as *Protaetia* sp. and *Hypomeces squamesus*. It spread very fast to full fruit within 12-24 hours. Red flesh DF variety is shown to be more susceptible than white flesh (Hieu *et al.*, 2014).

Causal agent: Red flesh DF causal agents were identified as *Erwinia chrysanthemi* and *Rhizopus* sp., while white flesh was only *E. chrysanthemi* (Hieu *et al.*, 2011).

Disease development and spread: Regularly, disease develops and spreads during the rainy season. Heavy rain and low temperatures favor sporulation and infection. Bacteria may survive in decay infected organs, debris, soil, water, etc. Disease can spread by wounding insects (*Protaetia* sp. and *Hypomeces squamesus*).

Disease management

Cultural practices: (i) Pruning and removing infected cladode, bud and fruit and opening up the canopy to allow better air movement will significantly assist control. To reduce infection, affected organs retained in the canopy should be removed to reduce spore numbers. The bacterium can enter the vines via wounds, so disinfect secateurs using bleach or household spirits between diseased and healthy trees when pruning, to avoid the spread of the disease. Pruning should be followed with an application of a protective fungicide; (ii) Petals should be removed in proper time (2-3 days after flowering depend on season); (iii) Avoid over irrigation canopy of infected trees and should not be done in late afternoon; (iv) Wind break should be involved when growers starting new orchard; (v) To support the trees suppress infection, balance nutrient should be consider as best practices in orchard (Hieu *et al.*, 2015).

Biological control: High organic matter content plus antagonist fungi such as *Trichoderma* are strongly recommended for application.

Chemical treatment: Regular bactericide applications when infection conditions are favorable during rainy months are recommended such as Kasugamycin, Streptomycin sulfate, oxolinic acid. However, controlling wounding insects should be done in appropriate ways. Ensure that the label specifications are followed. In addition, to reduce the infection of the disease, the control of beetle like *Protaetia* sp. plays important role too, whether picking up by hand or using of cypermethrine, cyperan, etc.

Yellow cladode - brown spot (*Bipolaris crustacea* and *Fusarium equiseti*)

Yellow cladode- brown spot has widely spread attacking most of fruit growing plants in the South recently. All over the world, there are very few researches on this issue and some of them proved that light factor is relative to yellow cladode phenomenon (Mizrahi and Nerd, 1999; Merten, 2003; Thomson, 2002; Crane and Balerdi, 2005).

Symptoms of the disease: It is usually occurs in the dry season and mostly appears on the top of plants, initial symptoms appear on upper stem surfaces as small, pinpoint with reddish-brown in color. Scabs are usually surrounded by yellow halo and spots expand which will cause large yellow areas and finally secondary infection also attacks (special stem rot) during the rainy season (Hieu *et al.*, 2013). Yellow cladode - brown spot disease attack severely at different stages from young tree to old one and caused serious problem in reducing yield.

Causal agent: Results of isolation and identification of diseased samples from pitaya stem showed that *Bipolaris crustacea* and *Fusarium equiseti* were two main causal organisms which cause pitaya yellow cladode -brown spot.

Disease management: The efficacy of these antagonists was evaluated using an *in vitro* assay; the obtained results revealed that all the test treatment of *Bacillus subtilis*, *B. megaterium*, *Pseudomonas* sp. and SOFRI-Trichoderma could reduce mycelium growth (40-80% of mycelium growth inhibition) of both *B. crustacea* and *F. equiceti* at seven days after inoculated. Under laboratory conditions, several agrochemicals were evaluated for disease checking and showed that mancozeb (Man 80WP) and iprodione (Viroval 50WP) were the best treatments to completely inhibited mycelium growth of *B. crustacea* as compared to control. Meanwhile, Mancozeb + Metalaxyl (Ridomil 68WP), Fosetyl aluminium (Aliette 80WP) and Tebuconazole + trifloxystrobin (Nativo 750WG) showed no fungal growth thereby indicating 100 percent inhibition of *F. equiceti* (Hieu *et al.*, 2013).

Publicity

Through time, many publications have been delivered; the main publications mentioned here are:

- + Hand book for GAP fruit production. National Agriculture Publishing House, 2007.
- + Hand book for trainer for GAP fruit and vegetables (Training guidelines for trainer who are playing role as extension workers, technicians, members of Farming Association and etc.). National Agriculture Publishing House, 2008.
- + The Pitaya GlobalGAP quality manual both in English and Vietnamese languages have been updated in 2010.
- + The Citrus GlobalGAP quality manual (2009).
- + The Mango GlobalGAP quality manual (2009).
- + The Rambutan GlobalGAP quality manual (2012).
- + The Sweet Potatoes GlobalGAP quality manual (2013).

- + The Water Melon GlobalGAP quality manual (2013).
- + The Pineapple VietGAP quality manual, National Agriculture Publishing House, 2014.
- + Certification body and Certified Process for VietGAP and GlobalGAP: Q and A. National Agriculture Publishing House. 2014.
- + Technical Guideline on DF cultivation lit by Compact fluorescent lamps. National Agricultural University publishing House. 2015.

Besides that, Dr. Hoa also participated in the CARD – IPM project on citrus as the main author for the Manual quality production of citrus based on GLOBALGAP standards.

The Nelson Mail printed an article on the NZ project leader and his involvements with aid projects in July. The DF GAP project and donor recognition were included in the article. The article subsequently resulted in the project leader presenting a lecture at the Nelson Marlborough Institute of Technology on 10 August 2007 to 7 Vietnamese, 4 Cambodians, 4 Lao and 1 from Myanmar; all were government officials, some senior: – included Mr Bui Chi Kien from the International co-operation Department of MARD in Hanoi.

CONCLUSION

In Vietnam, at present, the area for DF is about 45,449 ha with a total production of 587,969 tons and the average area per household is 0.5- 1 ha. Recent concern over food safety, returns from pitaya, which got GAP certification could be significantly improved when small growers and exporters can gain access to new high value markets in Europe and North America. The development of safe horticultural models and implementation of GAP are becoming exaggerated with regards to its importance in the food supply chain. VietGAP issued by MARD in 2008 has become a priority and compulsory regulation in fruits producing and market displaying. In the development of GAP, many topics have to be covered: Field farmers' benchmarking survey; Selection of a packer/exporter and farmer group for the production; The DF quality manuals for the farmer were developed; The national personnel capacity building has been developed; There are three main production areas for DF in the Provinces of Binhthuan, Tiengiang and Longan provinces. By the year 2017, 10,083.5 ha had been certified for GlobalGAP/VietGAP. Of them, 9,700 ha in Binhthuan, 310 ha in Longan and 73.5 ha in Tiengiang province. In Vietnam, the quality systems for DF are formed from the central to local levels to manage production and distribution. MARD directs and gives policies to support the locals in producing DF under GAP standards, applying IPM in DF production in order to reduce pesticides and inorganic fertilizers, increase the use of organic matter. The DF is affected by number of diseases with causing the greatest losses both in the field and postharvest stages. The major field diseases in Vietnam are canker (*Neoscytalidium dimidiatum*), bacterial soft rot (*Erwinia chrysanthemi*), anthracnose (*Colletotrichum gloeosporioides*, *C. truncatum*).

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