

OF JICA-IPQTF PROJECT IN 2nd YEAR (JFY 2006)15th March, 2007**I. Inputs from JICA**

1. Dispatch of experts

- a) Fruit injury test: Dr. Kawakami Fusao
(4 months: 27/11/2005 - 27/3/2006)
(4 months: 26/11/2006 - 25/3/2007)
- b) Disinfections method by VHT: Mr. Miyazaki Isao
(4 months: 27/11/2005 - 27/3/2006)
(4 months: 26/11/2006 - 25/3/2007)
- c) Rearing method of test insect: Mr. Yoneda Masanori
(4 months: 27/11/2005 - 27/3/2006)
(4 months: 26/11/2006 - 25/3/2007)
- d) Coordinator: Mr. Koshida Ryu
(12 months: 21/3/2005 - 20/3/2007)
- e) Supervisors of VHT machines (Specialist of VHT machine and BIOTRON machine)
 - a) Mr. Takenoshita Hirofumi (1 month: 25/12/2005 - 24/1/2006)
 - b) Mr. Sakaguchi Masami (1 month: 25/12/2005 - 24/1/2006)
 - a) Mr. Takenoshita Hirofumi (1 week: 14/1/2007 - 19/1/2007)

2. Procured equipments

Japanese fiscal year (JFY) 2005

1) Equipment purchased in Japan :

Total amount of the equipments is 88,064,000 yen (equivalent to US\$788,963) and include 2 vapor heat treatment (VHT) machines, 1 temperature control chamber for fruit storage, 2 biotrons for insect rearing, 1 biotron for infested fruit, 2 hot water baths, 1 transformer of 150KVA, 1 stabilizer of 100KVA, 1 stabilizer of 50KVA, 50 cages for adult fly, 20 cages for pupation, 1 hybrid recorder, 18 sensors.

The ship of these equipments left Japan on 10th Dec 2005, and arrived the port Lotus in Southern on 21st Dec 2005. The equipments were transported to the Project site in the night of 26th December due to the traffic restriction of daytime. Two Supervisors of Sanshu company who were dispatched by JICA, 4 experts, and the counterparts of the Center supervised to accelerate the installation work.

2) Equipments purchased in VN

Japanese fiscal year (JFY) 2005

- 2-1) 1 diesel generator of 150KVA, 1 auto transfer switch (ATS) that were delivered on 16th September 2005 from HUU TOAN Company, and the installation were completed and inspected on 26th September 2005. Total amount US\$23,890.
- 2-2) 2 Incubator, 4 sets of microscope, 1 personnel computer, 1 printer, 1 portable PH meter, 1 digital refractometer, 2 firmness testers, 1 digital color meter, 1 magnetic stirrer, 2 electric thermos were delivered by VIET KHOA Company on 16th September 2005 and inspected. Total amount US\$17,974.
- 2-3) 3 Air conditioners for room, 1 digital camera, 3 electric balances, 3 automatic thermal hydro graph, 1 projector for PC, 1 portable screen, 2 standard thermometers, 1 dry box, 1 drying

shelf, 1 drill bit, 1 refrigerator, 2 folding carts, 1 electric drill, 2 vacuum cleaners, 1 juicer blender were delivered by HAI LY Company on 27th October 2005 and inspected.
Total amount US\$16,701.

Japanese fiscal year (JFY) 2006

Total amount of the equipments is 5,206,812 yen (equivalent to US\$44,525.5) purchased from 2 companies, delivered and inspected before 12th January 2007 that includes

1 digital acid meter, 1 stereoscopic microscope, 1 digital camera, 1 auto dry box, 1 illuminometer, 2 humidity controller machine, 1 computer, 1 printer, 1 standard thermometer, 2 firmness tester for soft fruit, 3 automatic thermal/hydro graph, 1 autoclave, 2 dehumidifier, and 1 deep freezer, parts and consumable good as yeast hydrolysate, polypropylene container for fruit storage, recording paper and ink ribbon cartridge for VHT recorder, Ion-exchange resin for VHT and Bitron,, fluorescent lamp, and glow lamp, and fixture for Biotron, adhesive bond (for rearing box), pen and recording paper for thermal/hydro graph, sterilized petri dish.

Besides the main equipments above, other apparatus, shelves, lighting fixtures, tables, chairs, etc necessary for the laboratories and activities of the Project were purchased by local cost in Vietnam.

3) Accompanied equipments

Japanese fiscal year (JFY) 2005

1st lot : Material/instrument belongs to the experts arrived on 23rd October 2005.

Total amount 622,275 yen (US\$5,575)

2nd lot : Newly purchased consumables/tools for activities of the experts arrived on 30th November 2005. Total amount 1,756,866 yen (US\$15,740)

3rd lot : Adhesive bond for making the rearing box arrived on 1st December 2005.

Total amount 33,200 yen (US\$297)

All the equipments of total amount 2,412,341 yen (US\$21,612) were received and checked on 23rd December 2005.

Japanese fiscal year (JFY) 2006

1st lot : Newly purchased consumables/tools for activities of the experts arrived on 22nd November 2006. Total amount 694,120 yen (US\$6,775)

2nd lot : Feed for adult fruit flies belongs to the experts arrived on 26th November 2006. Total amount 50,300 yen (US\$430)

Almost of the equipment are arranged and installed in the rooms as the Layout 1 and Layout 2 below.

3. Training

3-1) Technical training : The trainee below attended the 4months course of Thermal treatment for the disinfestations of fruit flies, in Okinawa, Japan

1st year : From 23/5/2005 to 8/9/2005

Ms. Nguyen Nhu Thanh: Officer of Plant Quarantine Sub Department (PQSD)

2nd year : From 23/5/2006 to 8/9/2005

Ms. Tran Thi Viet Ha: Officer of Post-Entry Quarantine Center N0.II (PEQC)

Mr. Dang Dang Quang: Officer of Plant Quarantine Sub Department (PQSD)

3-2) Study tour :

1st year : From 10/7/2005 to 23/7/2005

- 1) Mr. Nguyen The Phu: Deputy Director General of Plant Quarantine Department (PPD)
- 2) Ms. Luong Thi Hai: Head of Plant Quarantine Division (PPD)
- 3) Mr. Nguyen Huu Dat: Vice-Director of Post-Entry Quarantine Center No. II (PEQC)

2nd year : From 8/7/2006 to 22/7/2006

- 1) Mr. Hoang Trung: Vice head of Plant Quarantine Division (PPD)
- 2) Mr. Nguyen Van Nga: Director of Plant Quarantine Sub Department No.II (PQSD)
- 3) Mr. Ngo Van Ba: Director of Plant Quarantine Sub Department No.VI (PQSD)

II. Inputs from Vietnamese side

1. Infrastructure:

- 1) Allocation of the working office for 4 experts with telephone line and fax machine
- 2) Refurbishment of eight (8) laboratories with internal electricity and water system for the new equipments. However, JICA covered the cost for the water filter to assure the water quality required by the VHT and BIOTRON machine. Running test of the equipments have completed.
- 3) The installation of low voltage electric supply (electric post) has completed in the June of 2006.

The electric power is sufficient for the operation of all equipment of the project. In the case of power disruption, the activities keep continuing with auxiliary generator procured by JICA.

2. Allocation of counterparts (C/P)

Project director : Dr. Nguyen Quang Minh

Project manager:

Coordinator / Mr. Nguyen The Phu

Administrative officer in charge/ Mr. Hoang Trung

Technical officer in charge / Mr. Nguyen Huu Dat

Working Group :

General technique : Mr. Nguyen Huu Dat

Equipment : Ms. Nguyen Thi Viet Ha

Rearing : Mr. Chuong, Ms. Thanh, Mr. Quang, Mr. Chau, Ms. Oanh, Ms. Huyen
(Mr. Chuong deceased on 21/12/2006)

Experiment: Mr. Nam, Ms. Ha, Ms. Oanh, Ms. Huyen, Mr. D.Quang, T.Quang, Mr. Chau

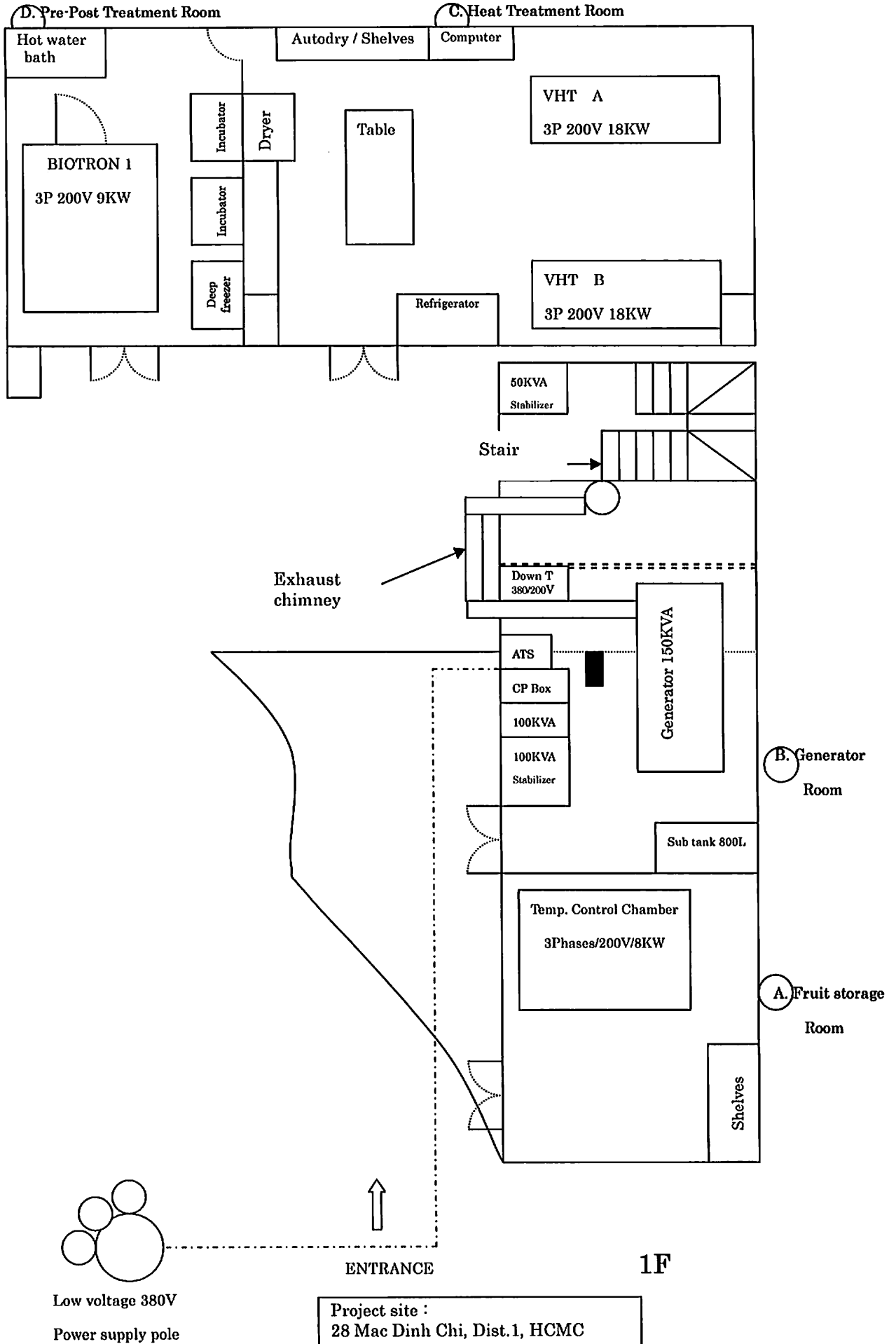
Reporting: Mr. Dat. Ms. Hoa, Ms. Hien

Water&Electricity : Ms. Hau, Mr. Binh

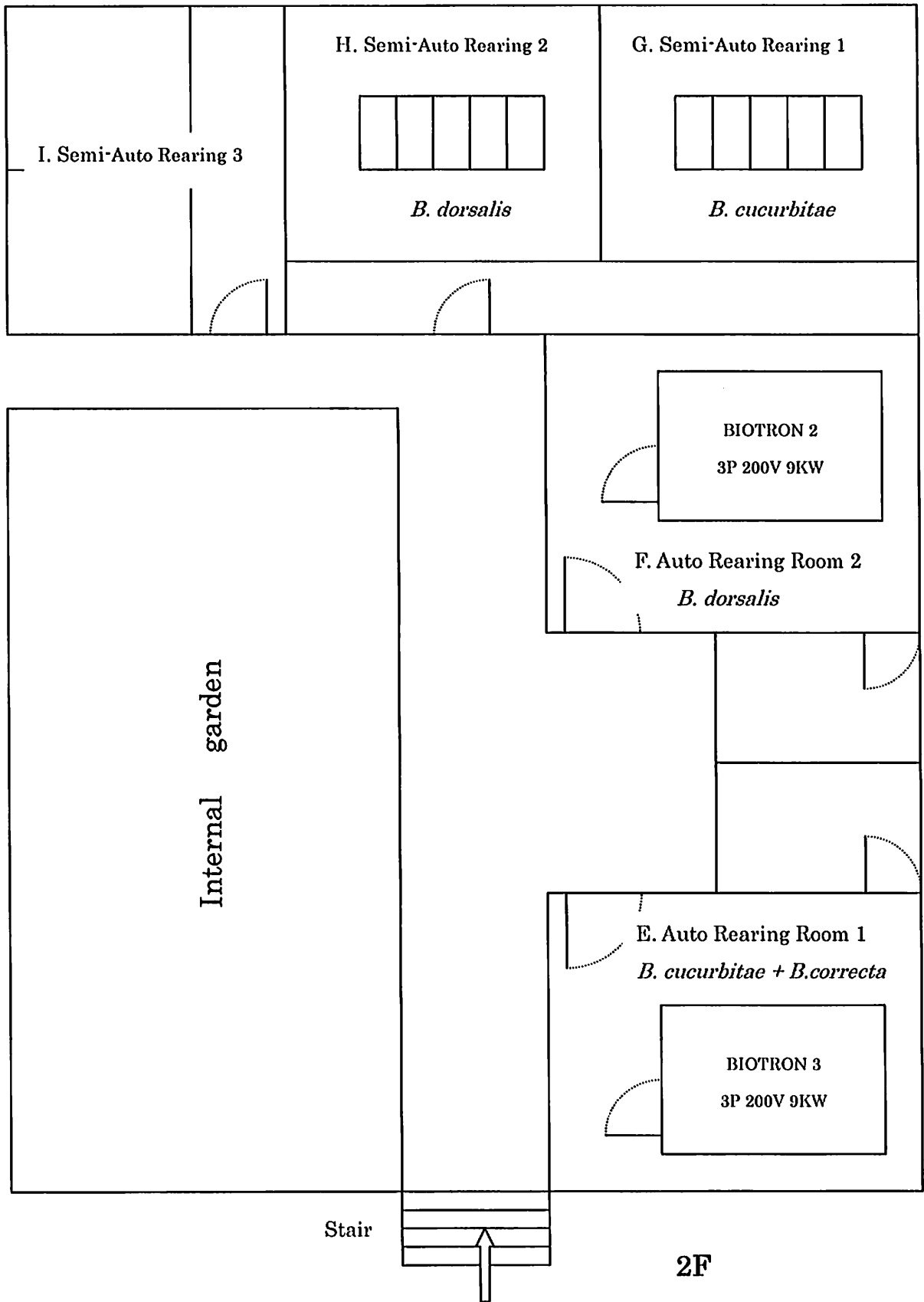
3. Activities:

- 1) Colony establishment: 3 colonies of fruit flies were established
Bactrocera dorsalis, *B. cucurbitae*, *B. correcta*
- 2) Fruit supply: The technical procedures were secured for the constant supply of fruits that meet the quality standard required for the experiment.
- 3) First on-site training by Japanese experts for Vietnamese staffs
- 4) A lot of the series of experiment have been implemented on schedule.

**LAYOUT 1 : POST ENTRY QUARANTINE CENTER No.II
INSTALLATION OF EQUIPMENTS AT FIRST FLOOR (1F)**



LAYOUT 2 : POST ENTRY QUARANTINE CENTER No.II
INSTALLATION OF EQUIPMENTS AT SECOND FLOOR (2F)



Project site :
28 Mac Dinh Chi, Dist.1, HCMC

ACTIVITIES AND PROGRESS

2nd JFY 2006 Joint Coordinating Committee Meeting of the project for improvement of plant quarantine treatment techniques against fruit flies on fresh fruits

Presented by : Mr. Nguyen Huu Dat

On behalf of organizer team, I would like to thank distinguished guests and participants for finding in your busy schedule to attend the JCC meeting.

On January 14, 2005 at Plant Protection Department of Ministry of Agriculture and Rural Development, Mr. Hiroshi IZAKI – Senior Deputy Resident Representative of JICA Vietnam Office and Mr. Nguyen Quang Minh – Director of Plant Protection Department signed the R/D on the Project for Improvement of Plant Quarantine Treatment Techniques against Fruit Flies on Fresh Fruits. Upon this significant point, the project has been officially started and lasted for 3 years (3/2005-3/2008) at Post Entry Quarantine Center II belonging to Plant Protection Department.

1st annual JFY 2005 joint coordinating committee meeting of the Project was held on March 16, 2006 (last year) at Post Entry Quarantine Center II .

Today, on March 15, 2007, once again at Post Entry Quarantine Center II, **second annual JFY 2005 joint coordinating committee meeting of the Project** has been held. The meeting will be witnessed by officials of Ministry of Planning and Investment, Ministry of Agriculture and Rural Development as Vietnam counter part representatives, and Representatives of Consulate General of Japan in HCM city, JICA Senior Deputy Resident Representative as Japan counter part representatives.

Background of the project

As a member nation of such regional and international organizations as Asia and Pacific Plant Protection Commission (APPPC) and ASEAN, Vietnam is becoming more active in international trade of agricultural products including tropical fruits. One of the key factors in promoting tropical fruit trade is to protect plants from pest damages and to improve disinfestation service and accordingly meet disinfestation requirements set by importing countries.

However, plant quarantine system and technical skills of quarantine staff are still not sufficiently developed to meet with the challenges of international trade. As a result, a lot of potentials for exporting fruit and increasing added value to those agricultural products have not been realized.

In this context, to harmonize the plant quarantine system in Vietnam with international standards, Plant Protection Department, Ministry of Agriculture and Rural Development of

Vietnam requested the Government of Japan to provide technical assistance in fruit fly disinfestations on fresh fruits.

Project Purpose

Vietnamese staff is capable of applying disinfestation technique of fruit flies that complies with international standard to improve Vietnamese dragon fruit's access to international market.

Project Activities

- 1-1 To identify species of fruit flies reared in laboratory
- 1-2 To establish rearing environment at constant temperature, humidity and daily light-dark period in laboratory
- 1-3 To establish rearing method for all growing stages of fruit flies
- 2-1 To determine vapor heat treatment condition (mortality test)
- 2-2 To determine vapor heat treatment (fruit injury test)
- 3-1 To continuously record examination data
- 3-2 To analyze examination data
- 3-3 To theoretically arrange analytical data

Outputs of the Project

- (1) Rearing method for fruit flies in laboratory is established
- (2) Method for vapor heat treatment disinfestation and its condition are determined
- (3) The system which stores examination data and analysis results is built and utilized by Vietnamese counterparts

Duration of the Project

3 years starting from March 2005

Site of the Project

Post-Entry Quarantine Centre No. II belonging to Plant Protection Department

Project progress

a/ Technical issues:

- a.1/ Colonies establishment : 3 colonies were established and reared in constantly healthy condition: *B dorsalis*, *B correcta*, *B cucurbitae* (automatically and semi-automatically)
- a.2/ Fruit supply: technical procedure was well accomplished (fruit delivery is being proceeded well, fruit supplied meet technical requirements of both injury tests (2005) and mortality tests (2006))
- a.3/ 4 month Technical trainings for 3 staff in Okinawa (Japan) were accomplished: 1 staff during the first training (2005) and 2 staff during the second one (2006)
- a.4/ Study Tour on Plant quarantine Administration for 6 Vietnamese managers in Japan were accomplished: 3 managers during the first study tour (2005) and 3 managers during the second one (2006)
- a.5/ First on-site training (2005) made from 4 Japanese experts for 8 Vietnamese staff: was

accomplished

Second on-site training (2006) made from the 4 former Japanese experts for 8 Vietnamese staff has been being accomplished

a.6/ First series of experiment on fruit injury (12/2005-4/2006) and the second ones on Vapor Heat Treatment conditions determination (11/2006-3/2007) including the Hot Water Dipping Tests, Susceptibility Tests and part of Small Scale Mortality Tests have been implemented successfully.

b/Non-technical issues:

Year of 2005:

b.1/ Transportation of imported equipments from the port to the PEQ Center II was accomplished

b.2/ Equipment for 8 labs and then making them in activation were accomplished.

b.3/ Repair of 8 labs in terms of electricity and water system to accommodate new equipments was accomplished

b.4/ Fruit supply contract for injury tests was well accomplished .

b.5/ Generator establishment and its activation were accomplished.

b.6/ Recruitment of one electricity technicians for daily in-lab electric surveillance was accomplished .

Year of 2006:

b.7/ Electric power supply post establishment was accomplished in June 2006, making all machines and equipments of the project in the whole building, in capaciously and smoothly activation for all day round without abnormal trouble occurrences since then.

b.8/ Fruit supply contract for mortality tests has been well accomplished

b.9/ Periodical maintenances for all machines, making them ready for work at any time.

c/ Difficulties and advantages:

Difficulties:

In 2005, although we put a lot of effort into the project, unexpected issue regarding to electric power supply post establishment occurred. Hence it followed that the delay for some planned experiments that really needed to be supplied by enough electric power for machines and equipments operation was as an obvious consequence.

Time for starting to develop all project activities mostly focuses at the end of Vietnamese fiscal year and coincides with the time when Vietnam counterparts have to draw up all final financial balance-sheets.

Advantages:

Timely decision, help and support from MARD, PPD and other related organization leaders for solving the problems.

The establishment of electric power supply post was accomplished in June 2006. This has made all machines and equipments of the project, in the whole building, in a state of

capacious and smooth activation all day round, without abnormal trouble occurrences since then. So not only the remaining experiments of 2005, but also the planned ones for 2006 have been smoothly implemented timely as scheduled.

d/ Comments:

Both Vietnam and Japan counterparts have realized their best all of their possible duties.

Japanese scientists have worked diligently and actively, and treated very intelligently all potential situations during experiments implementation.

Vietnamese staff have caught quickly all theories, techniques and practices taught by Japanese facilitators. They have worked collectively, cooperatively and with a disciplinary spirit.

The results obtained is prideful and could be assessed as excellence. In this tendency, the project could be over in success, reach the planned purposes next year.

e/ Suggestions:

Continue to receive the concerns and supports from MARD, PPD and other related organization leaders for completing the coming third year project.

Finally, I'm very honored to make the presentation on "activities and progress of project implementation" in this joint coordinating committee meeting today.

Thank you for your attention.

JICA
PROJECT FRAME WORK AND PROGRESSING
 Improvement of Plant Quarantine Treatment Technique
 against Fruit Flies on Fresh Fruits



Improvement of Plant Quarantine Treatment Technique
 against Fruit Flies on Fresh Fruits

1. Outline of the Project
2. Procedure for Disinfestation Technology Development
3. Activity of Short Term Experts

Improvement of Plant Quarantine Treatment Technique
 against Fruit Flies on Fresh Fruits

1. Outline of the Project
2. Procedure for Disinfestation Technology Development
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Improvement of Plant Quarantine Treatment Technique
 against Fruit Flies on Fresh Fruits

1. Outline of the Project



<Project Purpose>

Vietnamese staff is capable of applying disinfestation technique of fruit flies that complies with international standard to improve Vietnamese dragon fruits' access to international market.

Improvement of Plant Quarantine Treatment Technique
 against Fruit Flies on Fresh Fruits

1. Outline of the Project



<Project Site>

Post-Entry Plant Quarantine Center No.II,
 (Ho Chi Minh City, Vietnam)

<Term of Cooperation>

Three years, March 2005 – February 2008

Improvement of Plant Quarantine Treatment Technique
 against Fruit Flies on Fresh Fruits

1. Outline of the Project

<Dispatch of Experts>

Short term experts (3 x 4 months x 3 years)
 Project coordinator

<Provision of Machinery and Equipment>

Vapor heat treatment system, Biotron, etc.

<Counterparts Training in Japan>

From 7 to 9 persons

<Dispatch of Mission>

Final evaluation: Dispatch before half year of a project end, or when necessity arises

Improvement of Plant Quarantine Treatment Technique against Fruit Flies on Fresh Fruits

1. Outline of the Project

<Project Purpose>

Vietnamese staff is capable of applying disinfestation technique of fruit flies that complies with international standard to improve Vietnamese dragon fruits' access to international market.

Lifting import ban for Vietnamese Dragonfruit in Japan



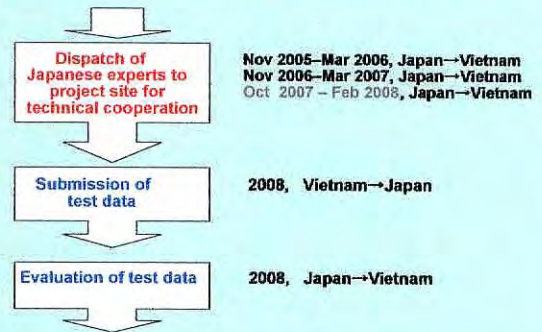
Improvement of Plant Quarantine Treatment Technique against Fruit Flies on Fresh Fruits

1. Outline of the Project
2. Procedure for Disinfestation Technology Development
3. Activity of First Short Term Experts

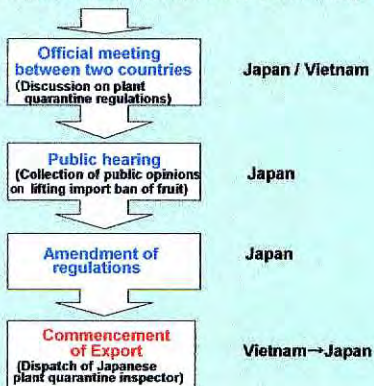
2. Procedure for Disinfestation Technology Development
<Implementation of technical cooperation by Japanese experts>



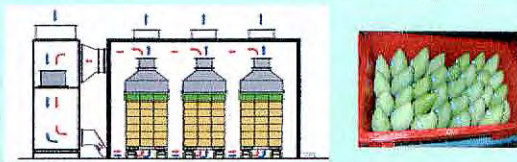
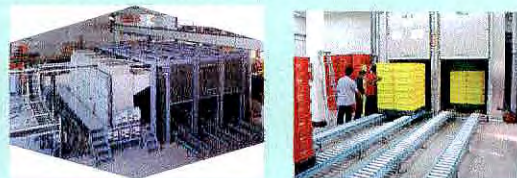
2. Procedure for Disinfestation Technology Development



2. Procedure for Disinfestation Technology Development



Commercial scale VHT facility



2. Procedure for Disinfestation Technology Development

Determination of target commodity, pests and method of disinfestation
 (Dragonfruit *Hylocereus undatus*, *B. dorsalis*, *B. cucurbitae*, VHT)



Hylocereus undatus



Hylocereus costaricensis



Selenicereus megalanthus

2. Procedure for Disinfestation Technology Development

Determination of target commodity, pests method of disinfestation
 (Dragonfruit *Hylocereus undatus*, *B. dorsalis*, *B. cucurbitae*, VHT)



B. dorsalis

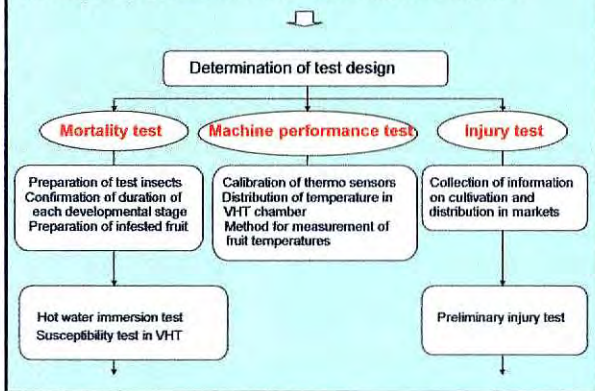


B. cucurbitae

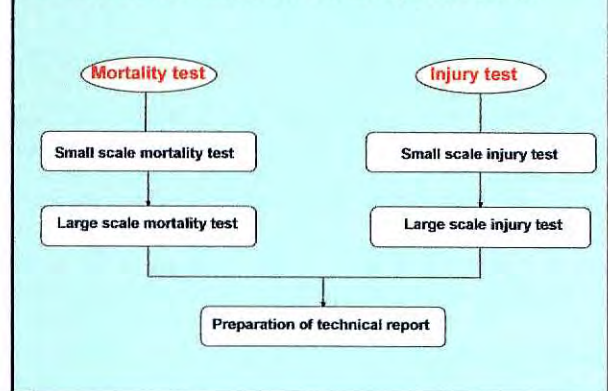


B. correcta

2. Procedure for Disinfestation Technology Development



2. Procedure for Disinfestation Technology Development



Improvement of Plant Quarantine Treatment Technique against Fruit Flies on Fresh Fruits

1. Outline of the Project
2. Procedure for Disinfestation Technology Development
3. Activity of Short Term Experts

Short Term Experts

Dr.Fusao Kawakami Japan Fumigation Technology Association

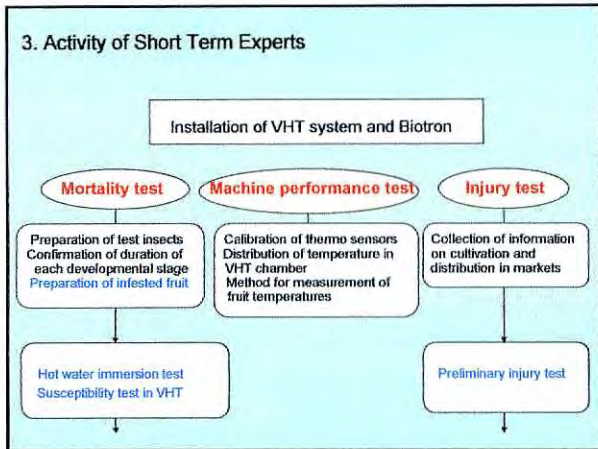
Mr.Masanori Yoneda Kobe Plant Protection Station, MAFF

Mr.Isao Miyazaki Naha Plant Protection Station, MAFF

Project Coordinator

Mr.Ryu Koshida





3. Activity of Short Term Experts
 <Dec 2005 – Jan 2006, in the first year>
Installation of machinery

VHT system, Biotron, Down transformer
 Cold storage chamber, Stabiizer, Water bath, etc.

3. Activity of Short Term Experts
 <Dec 2005 - Mar 2006, in the first year>
Mortality test

(1) Identification of rearing fruit flies
 (2) Larval developmental test in artificial diet
 (3) Confirmation of oviposition depth and larval inhabited place in dragonfruit

3. Activity of Short Term Experts
 <Jan - Feb 2006, in the first year>
Machine performance test

(1) Temperature calibration for VHT system and hybrid recorder
 (2) Demonstrative test for converted relative humidity value on VHT system
 (3) Confirmation for measurement of fruit temperature
 (4) Confirmation for temperature distribution in VHT chamber

3. Activity of Short Term Experts
 <Feb-Mar 2006, in the first year>
Injury test

(1) Preliminary injury test

3. Activity of Short Term Experts
 <Dec 2006 - Mar 2007, in the second year>
Mortality test

(1) Hot water immersion test
 (2) Susceptibility comparative mortality test
 (3) Preliminary small scale mortality test

3. Activity of Short Term Experts

<Mar 2007, in the second year>

Injury test

(2) Preliminary small scale injury test



3. Activity of Short Term Experts

<Jan 2007, in the second year>

Machine maintenance




JICA
REPORT ON TECHNICAL ACTIVITIES
Improvement of Plant Quarantine Treatment Technique
against Fruit Flies on Fresh Fruits



2. Preparation of the Infested Fruit for the Mortality Test
 1) Investigation of the amount of oviposition, ratio of hatchability, pupation and adult emergence

Improvement of rearing method of fruit fly
 Rearing room and rearing cage



Experiments of development of heat disinfestation treatment for dragonfruit

1. Performance Tests for Vapor Heat Treatment Device (VHT System)

- 1) Temperature calibration for VHT System and hybrid recorder
- 2) Confirmatory test for converted relative humidity in VHT System
- 3) Measurement of fruit temperature
- 4) Confirmation of temperature distribution in VHT System
- 5) Comparative test of the fruit temperature rise during the heat treatment under different relative humidity
- 6) Confirmatory test for most sensitive point in temperature probe.

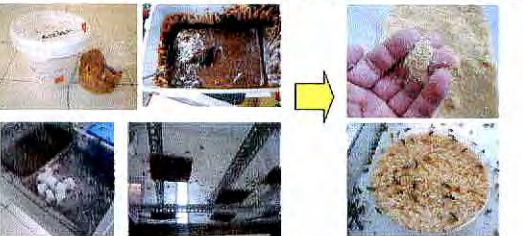
2. Preparation of the Infested Fruit for the Mortality Test

- 1) Investigation of the amount of oviposition, ratio of hatchability, pupation and adult emergence
- 2) Investigation of the oviposition depth and the larval inhabited part in dragonfruit
- 3) Making the infested fruit by the artificial inoculation method
- 4) Confirmation of duration of egg stage
- 5) Larval developmental tests in dragonfruit
- 6) Larvae development tests in artificial diet

2. Preparation of the Infested Fruit for the Mortality Test
 1) Investigation of the amount of oviposition, ratio of hatchability, pupation and adult emergence

Improvement of rearing method of fruit fly Feed for adult fly

Viscous autolyzed yeast, sugar Powder autolyzed yeast (AY-65) + sugar




Examinations of development of heat disinfestation treatment for dragonfruit

3. The Mortality Test

- 1) Hot water immersion test
- 2) Susceptibility comparative mortality test in VHT
- 3) Preliminary small scale mortality test
- 4) Small scale mortality test
- 5) Large scale mortality test

4. Fruit Injury Test


- 1) Preliminary injury test
- 2) Preliminary small scale injury test
- 3) Small scale injury test
- 4) Large scale injury test



2. Preparation of the Infested Fruit for the Mortality Test
 1) Investigation of the amount of oviposition, ratio of hatchability, pupation and adult emergence

Improvement of rearing method of fruit fly Larval artificial diet

Carrot diet Wheat bran diet



<Components of wheat bran diet>

- Wheat bran: 175g
- Sugar: 50g
- Dry yeast: 35g
- Toilet paper: 25g
- Sodium benzoate: 0.75g
- HCl (1N): 20ml
- Water: 650ml

2. Preparation of the Infested Fruit for the Mortality Test

6) Larvae development tests in artificial diet (wheat bran)

Bactrocera dorsalis

Bactrocera cucurbitae

Bactrocera correcta

Days after oviposition

3. The Mortality Test

1) Hot water immersion test

Hot water treatment of test insects

Temperature: 46.0°C

Exposure time: 2,4,6,8,10,12, 14,16,18,20 min.

Replication: 3

3. The Mortality Test

1) Hot water immersion test

Which species of fruit fly is the most tolerant of heat?

B. dorsalis *B. cucurbitae* *B. correcta*

Hot water treatment

Temperature: 46.0°C

Exposure time: 2,4,6,8,10,12, 14,16,18,20 min.

Replication: 3

Water bath [46.0°C]

Egg (young, mature)
1st instar larva
2nd instar larva
3rd instar larva

3. The Mortality Test

1) Hot water immersion test

Storage of insects after hot water treatment

3. The Mortality Test

1) Hot water immersion test

Preparation for test insects

1st instar 2nd instar 3rd instar

3. The Mortality Test

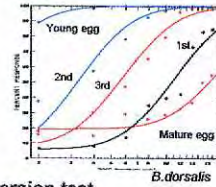
1) Hot water immersion test

Mortality check

3. The Mortality Test

1) Hot water immersion test

Results



Results of **probit analysis** (convert doses to logarithms) in hot water immersion test

Bactrocera dorsalis

Developmental stage	Estimated lethal time (min)						Regression				Chi-squared goodness-of-fit test			
	LT50	95%CI	LT85	95%CI	LT99	95%CI	Slope ± SE	Intercept	r ² (rate of slope)	Chi-square	Degree of freedom	p	Heterogeneity factor	
Young egg	1.03	(0.69-1.28)	2.76	(2.48-3.18)	4.15	(3.53-5.53)	3.831 ± 0.511	-8.044	0.272	0.953	8	p<0.05	0.119	
Mature egg	22.66	(19.08-24.06)	78.16	(45.25-422.56)	130.05	(63.69-1219.08)	3.059 ± 0.308	-4.145	7.680	22.757	8	p<0.05	2.670	
1st instar	11.31	(10.16-12.57)	24.21	(20.88-36.79)	33.19	(26.95-46.89)	4.978 ± 0.233	-5.244	21.340	47.101	8	p<0.05	5.898	
2nd instar	3.06	(2.49-3.63)	9.16	(7.75-11.56)	14.48	(11.51-20.32)	2.443 ± 0.146	-1.671	24.531	45.276	8	p<0.05	5.939	
3rd instar	6.24	(4.88-7.24)	13.25	(11.37-17.28)	16.10	(14.63-27.47)	5.031 ± 0.253	-4.062	19.875	74.303	8	p<0.05	0.283	

Bactrocera cucurbitae

Developmental stage	Estimated lethal time (min)						Regression				Chi-squared goodness-of-fit test			
	LT50	95%CI	LT85	95%CI	LT99	95%CI	Slope ± SE	Intercept	r ² (rate of slope)	Chi-square	Degree of freedom	p	Heterogeneity factor	
Young egg	NA	NA	NA	NA	NA	NA	NA ± NA	NA	0.000	0	8	NA	0.000	
Mature egg	10.81	(10.62-12.13)	17.69	(15.85-23.76)	22.21	(16.57-34.59)	7.438 ± 0.479	-7.590	15.526	75.498	8	p<0.05	9.4372	
1st instar	8.33	(7.27-9.17)	12.10	(10.81-15.06)	14.12	(12.21-19.26)	10.152 ± 0.479	-8.346	21.778	109.206	8	p<0.05	13.650	
2nd instar	5.12	(5.79-6.42)	8.81	(8.28-9.83)	10.25	(9.42-11.58)	10.367 ± 0.510	-8.153	20.318	25.102	8	p<0.05	3.1278	
3rd instar	4.82	(4.85-4.87)	7.38	(7.08-7.78)	8.83	(8.32-8.42)	8.906 ± 0.502	-8.085	17.734	2.925	7	p<0.05	0.418	

Bactrocera correcta

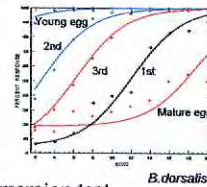
Developmental stage	Estimated lethal time (min)						Regression				Chi-squared goodness-of-fit test			
	LT50	95%CI	LT85	95%CI	LT99	95%CI	Slope ± SE	Intercept	r ² (rate of slope)	Chi-square	Degree of freedom	p	Heterogeneity factor	
Young egg	NA	NA	NA	NA	NA	NA	NA ± NA	NA	0.000	0	8	NA	0.000	
Mature egg	17.34	(15.72-18.21)	36.45	(28.88-42.44)	49.59	(38.09-104.82)	5.008 ± 0.877	-8.318	5.814	0.549	8	p<0.05	1.0585	
1st instar	18.02	(15.43-24.59)	36.60	(26.55-165.98)	49.10	(31.735-503.43)	5.344 ± 0.699	-6.711	7.811	20.004	5	p<0.05	4.8038	
2nd instar	10.87	(9.21-12.12)	20.90	(18.01-27.58)	27.41	(22.24-41.48)	5.781 ± 0.203	-8.001	10.065	66.188	8	p<0.05	8.5297	
3rd instar	11.81	(10.88-12.87)	23.86	(20.28-32.27)	32.90	(25.44-49.18)	5.371 ± 0.207	-5.758	17.515	38.305	7	p<0.05	5.4721	

NA: not available as an estimate could not be made from the data

3. The Mortality Test

1) Hot water immersion test

Results



Results of **logit analysis** (non convert doses to logarithms) in hot water immersion test

Bactrocera dorsalis

Developmental stage	Estimated lethal time (min)						Regression				Chi-squared goodness-of-fit test			
	LT50	95%CI	LT85	95%CI	LT99	95%CI	Slope ± SE	Intercept	r ² (rate of slope)	Chi-square	Degree of freedom	p	Heterogeneity factor	
Young egg	0.44	(-0.80-1.01)	2.88	(2.57-3.44)	4.25	(3.94-5.61)	1.205 ± 0.242	-0.521	4.692	0.483	8	p<0.05	0.390	
Mature egg	20.50	(18.22-24.59)	36.82	(30.34-53.84)	45.97	(38.69-70.88)	0.180 ± 0.018	-3.887	9.622	21.218	8	p<0.05	3.501	
1st instar	11.85	(10.92-12.93)	21.24	(19.44-23.94)	25.44	(22.78-30.54)	0.317 ± 0.012	-3.785	25.161	45.618	8	p<0.05	5.826	
2nd instar	3.83	(2.98-3.70)	6.94	(6.40-9.90)	12.08	(11.22-13.12)	0.528 ± 0.027	-1.777	19.307	6.137	8	p<0.05	1.017	
3rd instar	6.51	(5.00-8.40)	12.74	(11.05-13.73)	16.24	(15.07-17.76)	0.473 ± 0.028	-3.079	23.494	16.782	8	p<0.05	2.088	

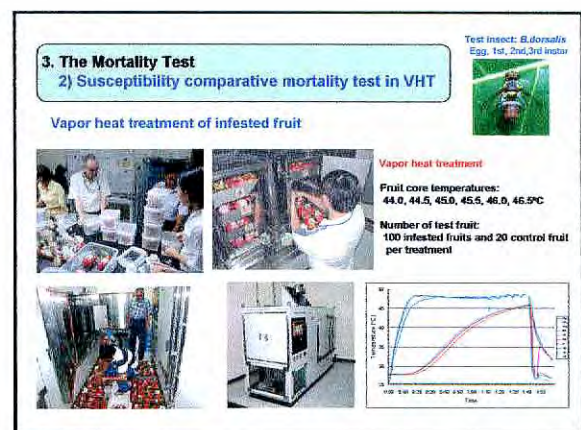
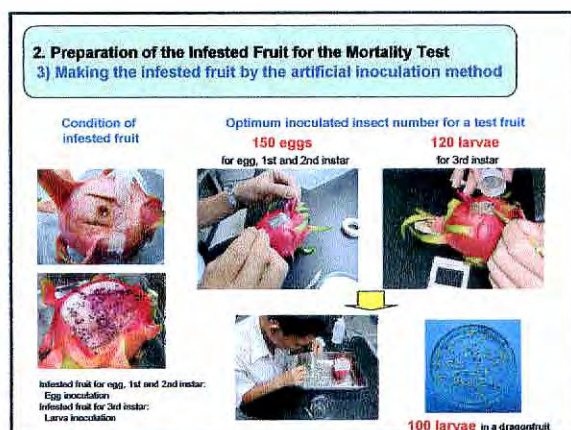
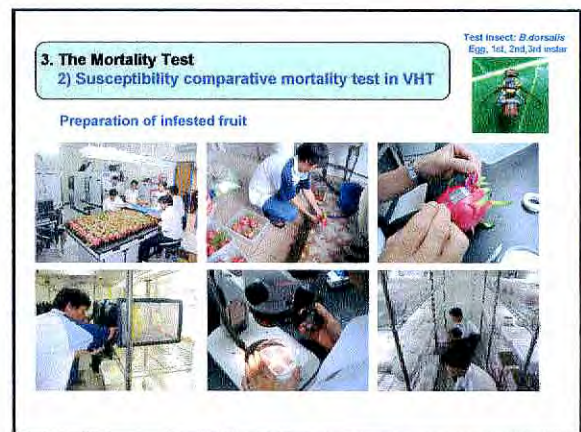
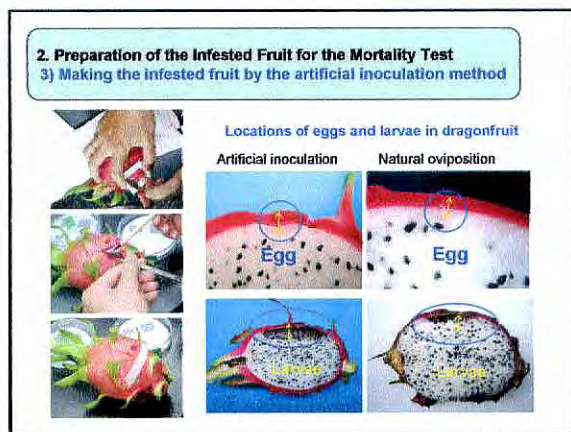
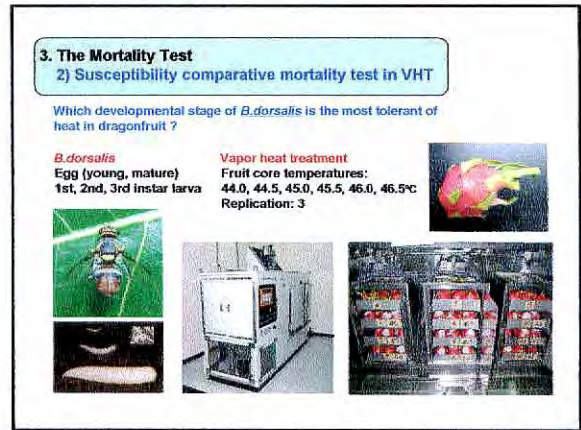
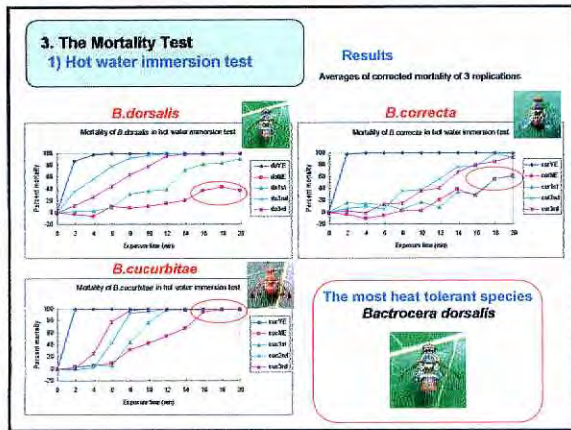
Bactrocera cucurbitae

Developmental stage	Estimated lethal time (min)						Regression				Chi-squared goodness-of-fit test			
	LT50	95%CI	LT85	95%CI	LT99	95%CI	Slope ± SE	Intercept	r ² (rate of slope)	Chi-square	Degree of freedom	p	Heterogeneity factor	
Young egg	NA	NA	NA	NA	NA	NA	NA ± NA	NA	0.000	0	8	NA	0.000	
Mature egg	11.82	(8.38-12.34)	17.60	(16.07-20.38)	21.28	(18.95-25.89)	0.448 ± 0.028	-4.631	12.696	52.852	8	p<0.05	6.907	
1st instar	6.42	(7.19-6.22)	11.93	(10.08-14.92)	13.65	(12.10-18.83)	0.845 ± 0.047	-7.118	12.617	112.676	8	p<0.05	14.084	
2nd instar	6.25	(5.62-6.58)	8.51	(7.88-9.59)	9.78	(8.89-11.37)	1.301 ± 0.076	-8.129	18.839	47.428	8	p<0.05	5.508	
3rd instar	4.82	(4.76-5.69)	7.26	(7.03-7.83)	8.63	(8.23-9.12)	1.243 ± 0.078	-8.122	17.221	1.078	7	p<0.05	0.154	

Bactrocera correcta

Developmental stage	Estimated lethal time (min)						Regression				Chi-squared goodness-of-fit test			
	LT50	95%CI	LT85	95%CI	LT99	95%CI	Slope ± SE	Intercept	r ² (rate of slope)	Chi-square	Degree of freedom	p	Heterogeneity factor	
Young egg	NA	NA	NA	NA	NA	NA	NA ± NA	NA	0.000	0	8	NA	0.000	
Mature egg	17.46	(15.76-18.05)	28.85	(25.48-39.70)	35.40	(30.16-47.51)	0.258 ± 0.038	-4.471	6.650	10.874	8	p<0.05	1.1356	
1st instar	17.69	(16.06-21.47)	29.51	(25.86-44.21)	35.98	(28.26-58.29)	0.258 ± 0.027	-4.661	9.586	20.008	5	p<0.05	4.1211	
2nd instar	11.15	(8.58-12.37)	19.70	(17.78-23.05)	24.50	(21.57-29.82)	0.244 ± 0.017	-3.825	20.775	60.158	8	p<0.05	7.5198	
3rd instar	12.28	(11.46-12.11)	20.79	(19.12-23.29)	25.58	(23.09-29.28)	0.348 ± 0.018	-4.240	21.652	27.788	7	p<0.05	3.8576	

NA: not available as an estimate could not be made from the data



3. The Mortality Test

2) Susceptibility comparative mortality test in VHT

Test insect: *B. dorsalis*
Egg, 1st, 2nd, 3rd instar

Storage of test fruit after vapor heat treatment

Air cooling: 30 min.
Keep fruit at 28°C
Egg and 1st instar: 5 days
2nd and 3rd instar: 4 days

3. The Mortality Test

3) Preliminary small scale mortality test

Test insect: *B. dorsalis*
1st instar larva

Determination of treatment condition

Temperature vs. Time graph showing heating curves for different treatments.

Fruit core temperature	Control	45.5°C	46.0°C	46.5°C	46.5°C	46.5°C	46.5°C	46.5°C
Holding time		0 min	0 min	0 min	10 min	20 min	30 min	40 min
Number of survivor	1,132	782	395	0	0	0	0	0
Corrected mortality	0%	30.3%	64.8%	100%	100%	100%	100%	100%
Number of test fruit	10	10	10	10	10	10	10	10

3. The Mortality Test

2) Susceptibility comparative mortality test in VHT

Test insect: *B. dorsalis*
Egg, 1st, 2nd, 3rd instar

Mortality check

1st instar

46.0c, 45.5c, 45.0c, 44.5c, 44.0c, Cont

4. The Fruit Injury Test

2) Preliminary small scale injury test

Establishment of avoidance method of heat injury

46.5°C 0, 30, 60 min holding time

46.5°C 30 min holding time

46.5°C 60 min holding time

3. The Mortality Test

2) Susceptibility comparative mortality test in VHT

Results

Percentage corrected mortality

Replication 1

Temp	YE	ME	1st	2nd	3rd
44.0	100.0	22.0	9.6	56.6	90.0
45.0	100.0	81.5	37.1	93.2	86.8
45.5	100.0	96.6	96.3	96.7	92.9
46.0	100.0	100.0	100.0	100.0	100.0
46.5	100.0	100.0	100.0	100.0	100.0

Replication 2

Temp	YE	ME	1st	2nd	3rd
44.0	99.5	34.8	9.7	60.5	40.1
44.5	100.0	55.6	27.5	57.9	39.1
45.0	100.0	70.0	28.1	91.7	72.6
45.5	100.0	66.3	75.9	99.7	65.9
46.0	100.0	99.5	100.0	100.0	100.0

Replication 3

Temp	YE	ME	1st	2nd	3rd
44.0	100.0	24.0	24.9	40.5	73.1
44.5	100.0	30.0	22.1	58.2	57.7
45.0	100.0	47.6	37.2	91.6	32.4
45.5	100.0	74.0	68.4	88.7	63.6
46.0	100.0	100.0	99.0	100.0	100.0

The most heat tolerant stage: 1st instar of *Bactrocera dorsalis*

Experiments of development of heat disinfection treatment for dragonfruit

3. The Mortality Test

- 3) Small scale mortality test
- 4) Large scale mortality test

4. Fruit Injury Test

- 3) Small scale injury test
- 4) Large scale injury test