ベトナム国
ミバエ類殺虫技術向上計画
第一次事前評価調査報告書

平成16年9月
(2004年)

独立行政法人　国際協力機構
農村開発部

農　村
ＪＲ
04-38

序　　文

ベトナム国は、自国における植物検疫システムを国際的なレベルと調和させるため、ミバエ類の殺虫分野に関して先進的な技術と豊富な経験を有する我が国に対し、「ベトナム国ミバエ類殺虫技術向上計画」に係る技術協力プロジェクトを要請してきました。

これを受けて国際協力機構は、平成16年8月8日から8月14日まで当機構ベトナム事務所長菊池文夫を団長とする事前評価調査団を現地に派遣しました。

同調査団は、ベトナム国関係者との協議及び現地調査を通じて、要請の背景、協力課題の絞込み、先方実施体制の確認を行い、プロジェクト基本計画等の案を作成しました。

本報告書は、同調査団による調査結果等を取りまとめたものであり、今後、本プロジェクトの実施の検討に当たり、広く利用されることを願うものです。

終わりに、本調査にご協力とご支援をいただいた内外の関係者に対し、心より感謝の意を表します。

平成16年9月

独立行政法人　国際協力機構
農村開発部
部長　　古賀 重成

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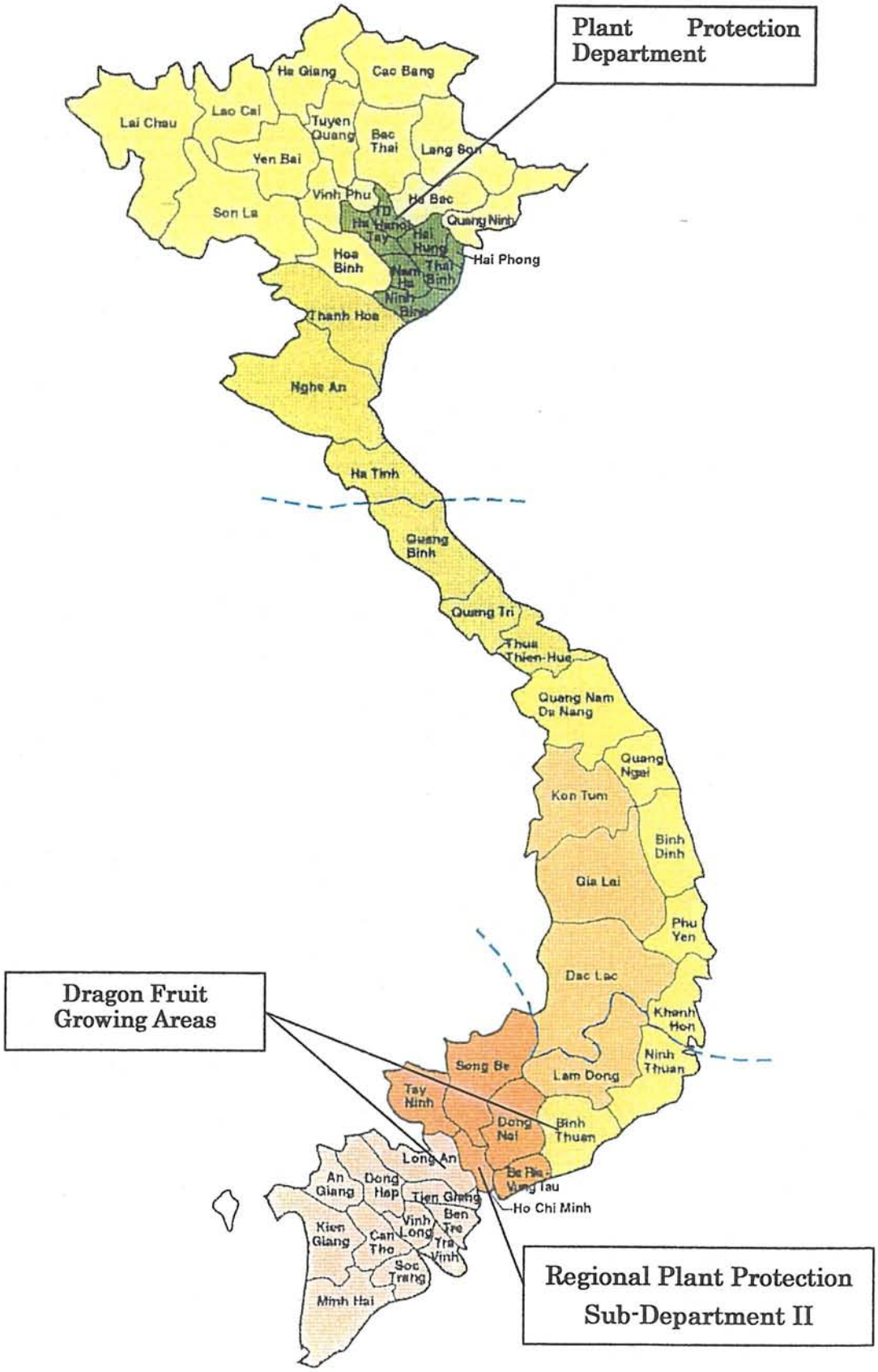
付属資料

ベトナム国地図


Plant Protection Department
Dragon Fruit Growing Areas
Regional Plant Protection Sub-Department II
Ha Giang
Cao Bang
Lai Chau
Lao Cai
Tuyen Quang
Bac Thai
Lang Son
Yen Bai
Vinh Phu
Ha Bac
Son La
Ha Tay
TD
Quang Ninh
Hai Hung
Hoa Binh
Thai Binh
Hai Phong
Nam Ha
Ninh Binh
Thanh Hoa
Nghe An
Ha Tinh
Quang Binh
Quang Tri
Thua Thien-Hue
Quang Nam Da Nang
Quang Ngai
Kon Tum
Binh Dinh
Gia Lai
Phu Yen
Dac Lac
Khanh Hoa
Song Be
Lam Dong
Ninh Thuan
Tay Ninh
Dong Nai
Binh Thuan
Long An
An Giang
Dong Hap
Tien Giang
Ba Ria - Vung Tau
Ho Chi Minh
Ben Tre
Vinh Long
Kien Giang
Can Tho
Tra Vinh
Soc Trang
Minh Hai

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殺虫調査室

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果実障害調査室

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写真 7：
２階ミバエ飼育室（３室）

写真 8：
ミバエ飼育用ケージ

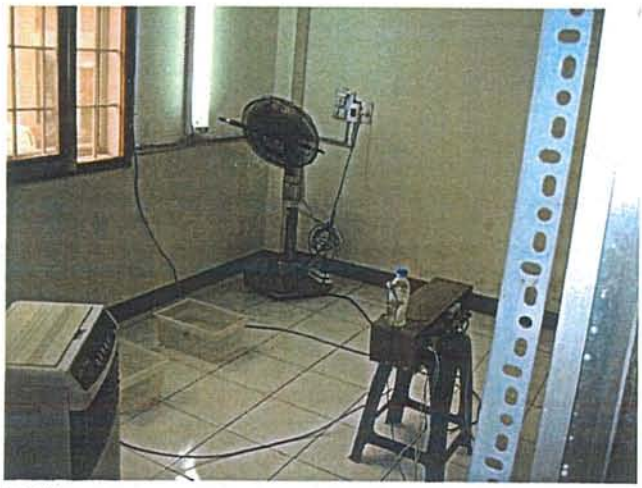

写真 9：
空調装置（温湿度調整）

写真 10：
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空調装置（湿度調整）

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第１章　事前評価調査団の派遣

１－１　調査団派遣の経緯と目的

ベトナム国は現在、様々な地域機関や国際機関に加盟し、農産物をはじめとした国際的な物資の流通が盛んになってきている。しかしながら、熱帯果実類の流通に必要不可欠な植物検疫システムについては、果実類に付着するミバエ類をはじめとする病害虫を効果的に防除する技術や、農産物の貿易を促進するための制度が十分に備わっていない。今後、熱帯果実類の円滑な輸出を図るためには、植物検疫における国際基準の要求事項を満たすことが最大の課題となっている。

このような背景のもと、ベトナム国農業農村開発省植物防疫局は、同国における植物検疫システムを国際的なレベルと調和させるため、ミバエ類の殺虫分野に関して先進的な技術と豊富な経験を有する我が国に対し、植物検疫処理技術等の助言と指導を要請してきた。

このため、今般、具体的なPO、PDM及び事前評価表を作成するためのデータを収集するとともに、実現可能な具体的な活動計画を策定するため関係者との協議を行い、最終的にプロジェクトの概要と活動についてミニッツに取りまとめることを目的として、事前評価調査団を派遣した。

＜これまでの経緯＞

2000

～2001 年　日本からベトナム国へ植物検疫に係る専門家を派遣（現状評価、改善策提言、国際水準に係る情報提供等）

2003 年 4 月　カイ首相訪日、検疫改善に係る協力を小泉首相に要請

2004 年 1 月　我が国への協力要請の概要をベトナム国が取りまとめ

2004 年 5 月　ベトナム国に対し本件の採択を通報

１－２　調査団の構成

ア）総括：菊地 文夫（JICA ベトナム事務所）

イ）プロジェクト計画立案：金田　昌士（農林水産省）

ウ）ミバエ飼育・消毒技術：川上　房男（農林水産省（専門家候補者））

エ）計画管理･業務調整：仲宗根　邦宏（JICA ベトナム事務所）

（＊内藤久仁彦専門家（農業･農村開発）も同行）

1－3　調査日程:平成16年8月8日(日)～平成16年8月14日（土）

8月8日（日）	11:00東京→14:20ハノイ(VN955)
8月9日（月）	9:30-　JICAベトナム事務所（菊地所長、仲宗根所員、金田団員、川上団員、内藤専門家）打合せ 11:00-　大使館表敬（菊森一等書記官） 14:00-16:00　農業農村開発省担当部局（植物防疫局、国際協力局）と協議
8月10日（火）	7:00ハノイ→9:00ホーチミン(VN741) 11:00-　JICA南部支所打合せ 14:00-17:00　農業農村開発省担当部局(植物検疫第2支局）と協議
8月11日（水）	9:00-15:00　試験予定施設･ミバエ飼育状況等視察及び打合せ（菊地所長　午後参団） 16:30-　団内打合せ
8月12日（木）	6:50ホーチミン→8:50ハノイ(VN217) 11:00-　ミニッツ作成 14:00-1600　農業農村開発省担当部局（植物防疫局、国際協力局）と最終協議、ミニッツ案作成
8月13日（金）	10:30-　ミニッツ署名 15:00-　大使館報告 23:15ハノイ→翌14日早朝東京(JL5136)（金田団員、川上団員）

1－4　主要面談者

●農業農村開発省　植物防疫局：Plant Protection Department（ハノイ）
･Mr. Nguyen Quang Minh (Director General)
･Mr. Nguyen The Phu (Deputy General Director)ホーチミン担当
･Mr. Dam Quoc Tru (Deputy Director General)
･Mr. Hoang Trung (Vice head Plant Quarantine Div.)

●農業農村開発省　植物検疫第2支局：Regional Plant Protection Sub-Department II （ホーチミン）
･Mr. Nguyen Van NGA (Director)
･Mr. Nguyen Huu DAT (Vice Director)

●農業農村開発省　国際協力局

・Ms. Dao Thi Loc (Senior Expert)

●日本大使館

・菊森　佳幹　　一等書記官

第２章　主な協議事項

２－１　技術協力の対象とする果実品目

ドラゴンフルーツ又はマンゴウ、あるいは両品目を対象とするか協議し、ドラゴンフルーツを対象果実として技術移転することで合意した。当初依頼のあったマンゴウについては、豪州、ニュージーランドとの協力により、ある程度成果が出ていることから、マンゴウについては必要に応じて技術的アドバイスを行う旨を口頭にて伝えた。

２－２　専門家派遣

日本側から(1)ミバエ類飼育技術、(2)殺虫試験、(3)果物品質･障害試験の各分野に対して３～４か月/年の専門家派遣を提案し、日本側提案どおりで合意した。

２－３　本邦研修

カウンターパート４名に対しての技術研修（1年目は２名、２・３年目は各１名）とプロジェクトマネージャ等を対象とした視察型研修（２～３名/研修で、計３～５名程度）を行う方向で協議し、双方合意した。

２－４　蒸熱処理機等の機材供与

豪州から供与された機材（豪州設計指導をもとにベトナム国にて製作）が使用可能か協議した。また、試験に必要な機材についても協議し、既設の蒸熱処理機は温度、湿度設定等の調整機能が十分に働かないため、本技術協力で活用することは困難であり、十分な機能を有する日本製の蒸熱処理機の導入など、必要機材の供与について合意した。なお、調達機材の詳細決定については、別途専門家による確認が必要であると思われる。

２－５　ベトナム国で発生しているミバエの種類

試験の対象が何種になるかで試験の規模が異なり、また、技術協力のスケジュールにも影響することから、ベトナム国内におけるミバエ類の発生状況について協議した。ベトナム国側は出典不明の文献を提出し、同国での発生は少なく、ドラゴンフルーツには寄生しない等の抽象的な説明に終始した。本調査において *B. dorsalis*、*B. cucurbitae* 及び *B. correcta* については把握したが、その他のミバエ類に関して正確な情報を入手する必要がある。

第３章　プロジェクト実施体制

３－１　責任機関及び実施機関の組織

（１）プロジェクト実施責任機関：農業農村開発省植物防疫局

（２）プロジェクト実施機関：農業農村開発省植物防疫局　植物検疫第２支局(ホーチミン)

＊ベトナム国側プロジェクト実施体制は４－２－（２）のとおり。

３－２　プロジェクトに対する予算措置

ベトナム国側投入については、以下のとおり。

（１）　カウンターパート配置

・プロジェクトコーディネーター(ホーチミン)：植物防疫局次長(Mr. Nguyen The Phu)

・プロジェクト　ハノイ担当：植物防疫局職員(Mr. Hoang Trung)

・技術担当主任(ホーチミン)：植物検疫第２支局 次長(Mr. Nguyen Huu DAT)

・技術スタッフ(ホーチミン)：植物検疫第２支局(４名)

・その他蒸熱処理試験サポートに係るスタッフ(数名程度)

（２）　プロジェクトオフィス、既存設備・資機材

（３）　電気、空調、水道、情報通信設備(電話、FAX、e-mail)

（４）　ローカルコスト負担

・プロジェクトランニングコストの負担(光熱水道料金等)

・蒸熱処理試験に必要な試験用果実準備に係る費用(日本側への費用一部負担の要請あり)

３－３　試験施設の状況

ホーチミン市の植物防疫局植物検疫第２支局の試験関連施設及び機材を調査した。試験施設は１階の３室（１７ m^2処理室、２０ m^2作業室、２０ m^2果実保管室)、２階のミバエ類飼育室４室（２０ m^2×２、１５m^2×２）及び寄生果実保管室２室（８ m^2×２）であった。２階の３室では *B. dorsalis* 、*B. correcta* 及び *B. cucurbitae* がそれぞれ飼育されていた。*B. cucurbitae* は寄主果実で飼育されており、最近飼育を開始したとのことであった。これらミバエ類の飼育は豪州の技術が導入されており、部屋の中央に大きな棚が設置され、１m^3大のケージ４個で飼育されていた。また、温度・湿度調整、光周期の調整や撹拌機などの設備があり、ある程度の飼育機能があることが分かった。しかし、試験が本格化すれば、部屋毎に生育日数に差を設けて、少なくとも３シリーズに分けてミバエを累代飼育することになるが、豪州方式は飼育ケージが大きいため、この飼育方式を導入することができない。したがって、日本式の小型のケージを数多く使用して飼育する方法に変更することになるが、この場合には飼育規模に合わせた空調設備や湿度調整などの検討が必要である。

また、１階の３試験室では、共用の小型の流しが１面のみ設置されていた。効率的な作業の実施のためには、新たに設置する必要があると考えられる。また、各実験室には大型の備品を含む機材が導入されることになるが、機材の配置に伴った電気（電気容量を含む）配線、水道などの工事が必要に

なると考えられる。

3－4　機材整備状況

1階の処理室には、豪州が設計してベトナム国が製作したとされる蒸熱処理機（内容積1m³、コントロールパネル盤及びコンピューター）1台が設置されていた。同処理機は人間がコンピューターを操作して温度・湿度を調節するシステムである。同処理機の機能を測るために、実際に室内空間の上部と下部の温度を測定して温度分布を確認した結果、2時間後でも温度差が約1．5℃見られるなど、温度差が非常に大きいことが判明した。さらに、同処理機の湿度調整機能は湿度５０％であり、蒸熱処理に不可欠な９０％の湿度が確保できないことも判明した。

このように、現在設置されている処理機は適切な温度調整ができなく、加えて一定の湿度も確保できないため、本プロジェクトの試験機として使用できないと考えられる。そのため、高性能の日本製の蒸熱処理機及びその付属設備を導入する必要があると考えられる。また、実際に使用する際には、同時並行的に各種の試験を実施するのに加え、故障なども考えられることから、蒸熱処理機は2台設置が必要と考えられる。

その他の機材については、小型の乾燥機、インキュベーター、冷蔵庫、冷凍庫が各1台見られたが、稼働していなく、中には故障している機材もあった。蒸熱処理機を運転するには電圧安定装置や自家発電装置が必要であるが、設置されていなかった。このように、試験で必要とされる機材のうち、顕微鏡など一部は使用できるが不足しているものも多い。

3－5　カウンターパート

ベトナム国側のプロジェクト組織は以下のとおり。

1）リーダー	ホーチミン市駐在の南部地域担当局次長　Mr. Phu
2）行政担当マネージャー	ハノイ植物検疫課長補佐　Mr. Trung
3）試験担当マネージャー	ホーチミンの植物検疫第2支局次長　Mr. Dat
4）カウンターパート	４名（ミバエ飼育、蒸熱処理、果実障害担当）

上記において、試験実務は及びカウンターパート4名に加え、必要に応じて要員を配置する。また、カウンターパート４名は本邦研修「植物検疫（ミバエ類殺虫技術）Ⅱ」に参加し、本邦と現地における日本側専門家の指導の下、ドラゴンフルーツに寄生するミバエ類の殺虫処理技術の開発を行うことになる。

第４章　プロジェクト協力計画の概要

４－１　プロジェクト基本計画

（１）　プロジェクトタイトル

ベトナム国ミバエ類殺虫技術向上計画

（２）　ベトナム国側カウンターパート機関

農業農村開発省植物防疫局

（３）　プロジェクトサイト

植物防疫局植物検疫第２支局（ホーチミン）

（４）　協力期間

2005年～2007年（３年間）

（５）　プロジェクトマスタープラン

１）上位目標

生果実に寄生するミバエ類に対する植物検疫処理技術の向上及びベトナム国における植物検疫システムの国際的レベルへの調和を図る。

２）プロジェクト目標

ベトナム国産生果実の国際貿易への参加を可能にするため、ミバエ類に対する消毒技術の開発ができるようになる。

３）プロジェクト成果

・ベトナム国産ドラゴンフルーツに対し国際基準に合致させるための新たな植物検疫処理技術の開発

・消毒技術開発能力の向上

４）プロジェクト活動

プロジェクト実行計画に従って実行（ミニッツ参照）

・供試果実と品種の決定

・供試ミバエの種類の決定

・供試虫の実験室における飼育方法の確立

・消毒方法及び消毒基準の決定

・殺虫試験計画の決定

・果実障害試験計画の決定

・データの整理及び報告書の作成

４－２　両国の投入

（１）　日本側の投入範囲

１）短期専門家の派遣

・供試虫の飼育法の確立：１名×３～４か月×３年

・蒸熱処理消毒試験　　：１名×３～４か月×３年
・果実障害試験　　：１名×３～４か月×３年
（注）必要に応じて供与機材のメインテナンスの技術者を追加派遣

２）日本における研修
ア）集団研修「植物検疫（ミバエ類殺虫技術）Ⅱ」（４名×４か月）
１年目は２名、２･３年目は各１名の計４名を受け入れることで合意した。
イ）日本の植物検疫視察研修（３～５名×１か月）
日本側は２～３名程度を考えていたが、ベトナム国側は５名を要望してきた。協議では、予算の問題もあり３～５名の範囲でJICA本部と調整すると回答しており、調整が必要である。

３）機材の供与
供給が必要と考えられる主な機材はミニッツのリストのとおり
（注）必要とされる施設及び備品は、プロジェクトの初期の段階で供与

（２）ベトナム国側の投入範囲
１）政府責任者、プロジェクトチーム及びカウンターパート
政府責任者は植物防疫局のMr. Minh、プロジェクトリーダーはホーチミン市駐在の南部地域担当局次長Mr. Phu、行政担当マネージャーはハノイ植物検疫課長補佐のMr. Trung、技術担当マネージャーはホーチミン市の植物検疫第２支局次長のMr. Dat及びカウンターパート４名（ミバエ飼育、蒸熱処理、果実障害担当）。ハノイ市との連絡調整はMr. Phuが担当する。
２）日本側専門家の事務室、実験室等における設備等の供与
３）プロジェクトのための運営費
４）試験に使用する果実の供給

４－３　プロジェクトの行政対応
ベトナム農業農村開発省植物防疫局長は、本プロジェクトの実施に全面的な責任を負う。日本側専門家は、本プロジェクトに関係する事項について、ベトナム国側カウンターパートに必要な技術的な助言と指針を付与する。JICA ベトナム事務所長は本プロジェクトの成功に向けて助言と調整の役割を担う。

第５章　協力分野の現状と課題

５－１　試験対象果実及び害虫

本調査において、ドラゴンフルーツに寄生するミバエ類の殺虫技術の開発を目的として、必要な技術協力を行うことで両国は合意した。検疫処理法はくん蒸剤処理、低温処理、蒸熱処理等があるが、くん蒸や低温による処理法は果実に障害が発生する恐れがあるため適用できない。このため、蒸熱処理による技術開発を目指すことになるが、ドラゴンフルーツを対象とした蒸熱処理はこれまで事例がなく、蒸熱処理された果実に障害が発生しないか不明である。そのため、ベトナムにおける当該果実の収穫後から輸入国における販売までの保管温度、期間等を含めた流通過程を把握し、各種条件を設定して障害の有無を確認する必要がある。

対象害虫は、既に発生が確認されている *B. dorsalis* 及び *B. cucurbitae* は試験の対象になる。これらの他に *B. correcta*、*B. calambolae*、*B. pyriforiae*、*B. zonata*、*B. tau* が発生している可能性が指摘されている。日本は、その国に発生している病害虫について危険度評価を行って試験の対象にすべきかどうか決定することになっている。今回の事前調査においては、ベトナム国側よりベトナム国での発生は少なく、わなで捕捉されるのみであり、果実には寄生していないなどの説明があったが、発生の根拠となる科学的な資料の提出は不十分であった。少なくとも、信頼性がある十分な資料がなければ試験を進める上で大きな支障が生じるため、この点をベトナム国側に理解させ、関係データを提出させる必要がある。

５－２　試験施設及び試験機材

ドラゴンフルーツに寄生するミバエ類を殺虫するには蒸熱処理が最も適した方法であると考えられ、本処理法を導入するためには高性能の蒸熱処理機が不可欠である。さらに、試験に関連する多くの器具機材、消耗品に加え、害虫の飼育施設、寄生果実の保管室、蒸熱処理室、殺虫効果の調査室、果実品質調査室、果実の保管施設等が必要である。

ホーチミン市の植物検疫局植物検疫第２支局の試験施設は１階の３室（蒸熱処理室、作業室、果実保管室）及び２階のミバエ飼育室４室及び寄生果実保管室２室である。ミバエの飼育室は日本式の大規模飼育法を導入する必要性があることから、温湿度調整、光周期の調整の変更が必要である。機材関係については、蒸熱処理機の付属備品として必要な電圧安定装置や自家発電装置はなく、また、冷蔵庫、乾燥機、冷凍庫、インキュベーター等は故障してほとんど使用できない。１階に３室あるが小型の流しが１面あるのみで作業上支障が生じる恐れがある。このように、試験室は大型の備品の導入を前提に機材の配置から検討する必要があり、電気や水道等についても新たに工事が必要になるであろう。

第６章　協力実施に当たっての留意事項

６－１　運営管理上の留意事項

６－１－１ 業務調整員の配置

プロジェクトサイトがホーチミン市であり、JICA 事務所のあるハノイ市から離れており、モニタリングが困難である。また、投入が主に短期専門家の派遣であることから、プロジェクトの予算の管理及びモニタリングについてベトナム国側だけでは困難と考えられる。本プロジェクトサイト機関はJICAのスキームに慣れておらず、またホーチミン市にはその他主だったJICAのプロジェクトがないことからも、プロジェクト運営、及びモニタリングのために、本プロジェクトにおける業務調整員の配置を検討する必要がある。

６－１－２ 日本側専門家等の執務室

日本側専門家及びJICA業務調整員の執務室及びプロジェクトチームとのミーティング室として１室が充てられることになっている。候補となっている部屋は、事務室として使用されており、近く改造を行い、空調装置も取り付けるとのことであった。電話は設置するが、通信費は日本側で負担願いたいとの要請があった。

６－１－３ 業務用車の配置

プロジェクト実施中は果実の調達、試験機材の調達、研究機関との情報交換、産地視察等のため車を使用する場面が多々生じる。このためには、移動手段を確保しておく必要があり、ベトナム国側は車の調達についてその役割を日本に期待していた。

６－２　技術分野における留意事項

６－２－１ 試験用果実の購入費の一部負担

消毒技術開発試験においては、試験用の果実と供試虫の供給が不可欠である。果実の供給体制が確立されていなければ、短期間の試験日程において成果を上げることは困難である。果実は高品質で薬剤無散布園から採取されたものでなければならない。また、必要量をいつでも入手できることが必要である。特に、ドラゴンフルーツは長期間の貯蔵が困難であるので、近隣の農園と契約して品質がそろった果実をいつでも確実に入手できる体制を整える必要がある。このため、購入費は通常よりも割高になる。果実の供給が試験の進捗動向を左右することから、本調査においてもベトナム国側に対して供給方を強く要請した。ベトナム国側はその重要性を認識するものの、日本に対して購入費の一部負担を要請している。試験に使用する果実の量については、その年にどのような試験を実施するか、試験の規模、反復等で異なる。蒸熱処理機の内容積は１㎥であり、他の消毒方法（低温処理、くん蒸剤による処理）に比べて処理する量は格段に少ないので、果実の購入費はそれほど高くないと考えられる。日本側も一部負担することを検討する必要がある。

第７章　調査団所感

ベトナム国は、熱帯果実類の輸出やミバエ類の防除問題について、豪州やニュージーランドによる何年かに亘る技術協力を得て課題の克服に取り組んできたが、依然として所定の成果が得られていなく、両国の技術協力も頓挫しているようである。

このような状況にあって、ベトナム国は日本の専門家による検疫処理技術指導、研修員の受け入れ、機材の供与を含めた技術的及び財政的な支援を得て、ベトナム国産の果実類を諸外国へ輸出する技術移転の実現に大きな期待を寄せていると感じた。このことは、ベトナム国側のプロジェクトの組織体制に裏付けされており、植物検疫局長をトップに、人望が厚いホーチミン市駐在の局次長をプロジェクトリーダーに任命し、日本の専門家リーダーのカウンターパート役、現場の総合指揮官、ハノイ市との調整役に当てることを表明した。技術サイドでは技術マネージャーを配置し、カウンターパート数人を固定して試験に対応させるとの強い姿勢を示した。この体制は、本プロジェクトを巡るハノイ市とホーチミン市の立場論での軋轢を排除し、プロジェクトの主たる実施場所に大きな権限を与えたことを示すもので、日本専門家チームとしては全てホーチミン市で話が済むことになり効率的に対処できるだろう。この点ホーチミンのプロジェクト組織は十分機能する体制が確立されていると感じた。

短期型のプロジェクトは限定された期間内に試験を実施することになるので、試験に必要な設備や材料を十分整え、試験に関係する必要事項を十分把握し、効率的に実施しなければ一定の成果を上げることはできない。試験施設及び機材については、ミバエの飼育は本格的な試験に備えて飼育法を改善する必要があり、空調、温湿度調整、光周期の調節に検討を要する。機材関係では、既設の蒸熱処理機は使用できず、また、付属として必要な電圧安定装置や自家発電装置がなく、冷蔵庫、乾燥機等の備品は故障してほとんど使用できないため、備品の多くは供与しなければならないだろう。また、備品の導入を前提に電気、水道工事を伴う試験室の整備が必要であると感じた。

試験に関係する必要事項については、今後、試験の対象となるミバエの種類を早急に決定しなければならない。これには、ベトナム国に発生しているミバエ類に関する科学的な根拠文献が必要であるが、資料の提出は不十分であった。信頼性がある資料がなければ試験を進める上で大きな支障が生じることは明白であるが、関係資料の提出を含めて情報提供には極めて慎重であるとの印象を受けた。

以上のとおり、ベトナム国側の本プロジェクトに対する組織体制は確立されたと思われるが、本来ベトナム国側が投入すべき事項のうち、試験場所の整備や試験に関係する必要事項の情報提供等への対応が不可欠であり、本プロジェクト体制が有機的に機能することを期待したい。

第８章　今後の検討課題及び行動スケジュール

８－１　今後の検討課題

今回の事前評価調査は、1週間という短い日程でハノイ市とホーチミン市を調査したことから、ホーチミン市の試験施設について十分な調査ができなかった。プロジェクトを推進する上で試験室の整備を含めて明らかにすべき事項が残っており、専門家２～３名を早急に１０～１２日程度ベトナムへ派遣して調査させる必要がある。主な調査、検討課題は次のとおりである。

８－１－１　機材供与リストの策定

ホーチミン市の試験施設は蒸熱処理や付属機器の供与、電源、水道、流し、大型機材、備品の配置、飼育室や試験のレイアウトを含めた多岐にわたる検討が必要であることが判明した。試験室や機材の整備は本プロジェクトの推進上最も重要であり、早急に機材供与リストを作成して日本で調達するもの、ベトナム国で調達できるもの等分類し、発注手続きを開始する必要がある。試験室の整備や機材の供与が遅くなれば、それだけ技術協力の実質的な期間が短縮されることになる。

８－１－２　試験対象となるミバエ種の決定

ベトナム国内におけるミバエ類の発生状況を正確に把握し、試験の対象となるミバエ類の種類を早急に決定する必要がある。これは、試験の対象が何種になるかで試験の規模が異なり、また、技術協力期間にも影響を及ぼすからである。本調査において *B. dorsalis*、*B. cucurbitae* 及び *B. correcta* については把握したが、ベトナムに発生しているとみられるその他のミバエ類（*B. carambolae*、 *B. zonata*、 *B. tau*、 *B. pyriforiae*）に関してベトナム国内の試験場や研究機関との間で意見の交換を行う中で正確な情報を入手する必要がある。

８－１－３　試験対象ドラゴンフルーツの管理状況の把握

試験対象果実がドラゴンフルーツに決定したが、本果実の生産状況、病害虫、収穫から販売までの保管方法等、流通に関する情報を入手する必要がある。特に、収穫後から輸入国での販売までの流通過程に関しては、試験を実施する上で不可欠な条件であり、これに付随して供与する機材の種類や数量が異なる可能性があるためである。

８－２　今後の行動スケジュール等

前記懸案課題の調査及び協議を含めた今後の行動スケジュールは次のとおりである。

８－２－１　第二次事前評価調査

再度、現地調査を 10～11 月に実施し、試験室の整備及び供与機材について確定させ、ベトナム国側が投入する事項と日本側が投入する事項を決定する。機材については日本で調達するものとベトナム国で調達するものに分類する等の作業を行う。

８－２－２　R/D 署名、機材等の調達手続き

12 月中に PDM、PO を整理して R/D 署名を行い、機材等の調達手続きを開始する。関係機材の入札仕様書作成、入札公示、入札、発注までを３月末までに終了させる。蒸熱処理機の現地導入、使用開始までに最低６か月要するので、処理機を使用した試験は早くとも 10 月末以降となる。

８－２－３　第１回専門家派遣

第１回専門家の派遣は、機材等の調達が予定どおり行われたとして、早くても 2005 年 11 月以降となろう。この時期の業務は、ミバエ飼育室の整備、試験室の整備、執務室の整備、機材の点検、関係機材、消耗品等の調達であり、具体的な処理技術に関する試験は困難と考えられる。したがって、実質的な技術協力期間は 2006～2007 年の２か年となるので、場合によっては専門家の滞在期間を延長する等の措置が必要になるだろう。さらに、今後、試験対象のミバエが最終的に何種になるか、新たに対象となるかも知れないミバエの大量飼育が可能かどうかなど、不確定要素もある程度考慮しておく必要がある。

付 属 資 料

1．ミニッツ

MINUTES OF MEETING BETWEEN THE JAPANESE PREPARATORY STUDY TEAM AND THE AUTHORISED REPRESENTATIVES OF THE MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT (MARD) OF THE SOCIALIST REPUBLIC OF VIET NAM ON JAPANESE COOPERATION FOR THE PROJECT FOR IMPROVEMENT OF PLANT QUARANTINE TREATMENT TECHNIQUE FOR FRUIT FLIES ON FRESH FRUITS

The Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Study Team (hereinafter referred to as "the Team"), headed by Mr. Fumio KIKUCHI, Resident Representative, JICA Vietnam Office to the Socialist Republic of Viet Nam from August 8 to August 13, 2004. The Team was dispatched for the purpose of collecting the further information about the Project above.

During its stay in the Socialist Republic of Viet Nam, the Team carried out field surveys and discussions on the Project with the authorized representatives of MARD of the Socialist Republic of Viet Nam.

As a result of the field surveys and the discussions, the Team and authorized representatives of MARD agreed to report to their respective governments the matters referred to in the document attached hereto.

Hanoi, August 13, 2004

Mr. Fumio KIKUCHI
Resident Representative
Vietnam office,
Japan International Cooperation Agency
Japan

Dr. NGUYEN QUANG MINH
Director General
Plant Protection Department
Ministry of Agriculture and Rural Development
The Socialist Republic of Viet Nam

Mr. BUI LIEM
Deputy Director General
Foreign Economic
Relations Department
Ministry of Planning and Investment
The Socialist Republic of Viet Nam

Dr. LE VAN MINH
Director General
International Cooperation Department
Ministry of Agriculture and Rural Development
The Socialist Republic of Viet Nam

ATTACHMENT

I. BACKGROUND

Vietnam is a member nation of the regional and international organization such as Asia and Pacific Plant Protection Commission (APPPC) and ASEAN, becoming active in international trade of agricultural products including tropical fruits. However, the plant quarantine system in Vietnam has not been developed well and it can be a key factor in the agricultural trade of tropical fruits and to protect plants from pest damages for facilitating the international trade. Therefore, it is a greatest subject to meet plant quarantine requirements as international standards in order to export fresh fruits from Vietnam.

In this context, to harmonize the plant quarantine system in Vietnam to international standards, Plant Protection Department, MARD, Vietnam requested technical advices and cooperation to Japan which has advanced technology and experiences in fruit fly disinfestations on fresh fruits.

II. PURPOSE OF THE PREPARATORY STUDY

The preparatory study team is dispatched to collect the specific data for Plan of Operations (PO), Project Design Matrix (PDM) and the preliminary evaluation sheet. At the same time, the team will discuss with relevant parties to prepare the final minutes describing the outline of the project and its activities resulting in the agreement with authorized representatives of MARD.

III. TENTATIVE FRAMEWORK OF TECHNICAL COOPERATION

1. Title of the Project

IMPROVEMENT OF PLANT QUARANTINE TREATMENT TECHNIQUE AGAINST FRUIT FLIES ON FRESH FRUITS

2. Vietnamese counterparts of the Project

Plant Protection Department, Ministry of Agriculture and Rural Development, Socialist Republic of Vietnam

3. Sites of the Project

Regional Plant Quarantine Sub-Department No. II, Ho Chi Minh City, Plant Protection Department, MARD

4. Term of the cooperation

From 2005 to 2007, Three (3) years

5. Master plan of the project

1) Overall Goal

Improvement of plant quarantine treatment technique and policies for fruit flies on fresh fruit and harmonizing the Vietnamese plant quarantine system in consistency with international standards for participation in international trade of fruits.

2) Purpose of the Project

Giving advice and guidance for developing the disinfestation technique of fruit flies on Vietnamese fresh fruits to participate in the international trade.

3) Outputs of the Project

- Development of a new treatment technology of Vietnamese Dragon fruit to meet phytosanitary requirements of international standard
- Improvement of the local plant quarantine staffs' capacity for the disinfestation technology

4) Activities of the Project

The project will be implemented in accordance with the Project Implementation Schedule as listed in Annex 1.

(1) Dispatch of short term experts in the field of plant quarantine

- Experts advices and guidance on the following items to develop the treatment technique of fruit flies.
  - + Decision of the test fruit and variety
  - + Decision of test species of fruit flies
  - + Establishment of laboratory population of the test insects
  - + Decision of the disinfestation method and approximate schedule
  - + Decision of the design of the disinfestation tests
  - + Decision of the design of the fruit injury tests
  - + Data arrangement and compile of the report

(2) Acceptance of Vietnamese plant quarantine trainees in Japan

+ Participation to JICA fruit fly group training course (4person X 4 months)
+ Observation training tour to Japanese Plant Quarantine (3-5person X 1 month)

5) Input from Japanese Government

(1) Dispatch short term experts for the following items

+ Rearing method of test insect: 1 person X 3-4 months X 3 years
+ Disinfestation method by VHT: 1 person X 3-4 months X 3 years
+ Fruit injury test: 1 person X 3-4 months X 3 years

Note: Short-term expert might be additionally designated for maintenance of the donated equipments, if necessarily.

(2) Training in Japan:

+ Participation to JICA fruit fly group training course (4person X 4 months)
+ Observation training tour to Japanese Plant Quarantine (3-5person X 1 month)

(3) Provision of equipment:

Main items of the equipment supposed to be provided are as listed in Annex 2.

Note: Necessary equipments and devices for the project might be additionally provided in early stage of the project.

6) Input from Vietnamese Government

(1) Counterpart personnel and firm communication channel between project site and person in charge in Vietnamese government.

One (1) Project Coordinator in Ho Chi Minh City, One (1) Administrative Manager in Hanoi, , One (1) Technical Manager and Four (4) counterparts in Ho Chi Minh City.

Note: Additional personnel for the tests might be needed.

(2) Office and laboratory equipments and facility for Japanese experts

(3) Running expenses for the project

(4) Providing for the test fruits

IV. ADMINISTRATION OF THE PROJECT

The Director General of Plant Protection Department, Ministry of Agriculture and Rural Development, Socialist Republic of Vietnam will bear overall responsibility

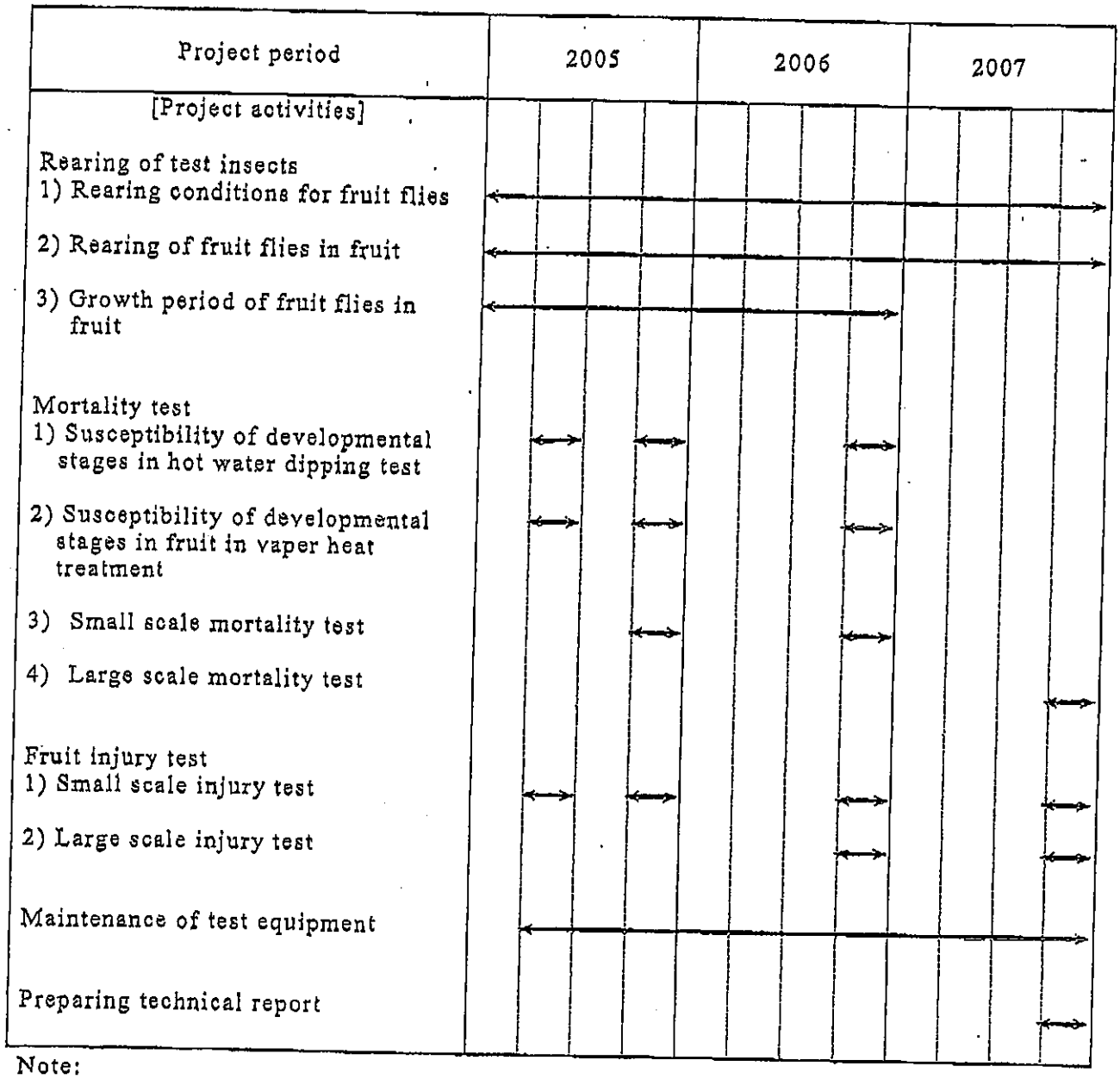
for the implementation of the project. The Japanese experts will provide necessary technical guidance and advices to Vietnamese counterpart staffs on matters relating to the project. The Resident Representative of JICA in Vietnam will undertake the role of an advisor and coordinator for successful implementation of the project.

Annex 1: Project Implementation Schedule
Annex 2: List of the main equipment

Annex 1

Project Implementation Schedule

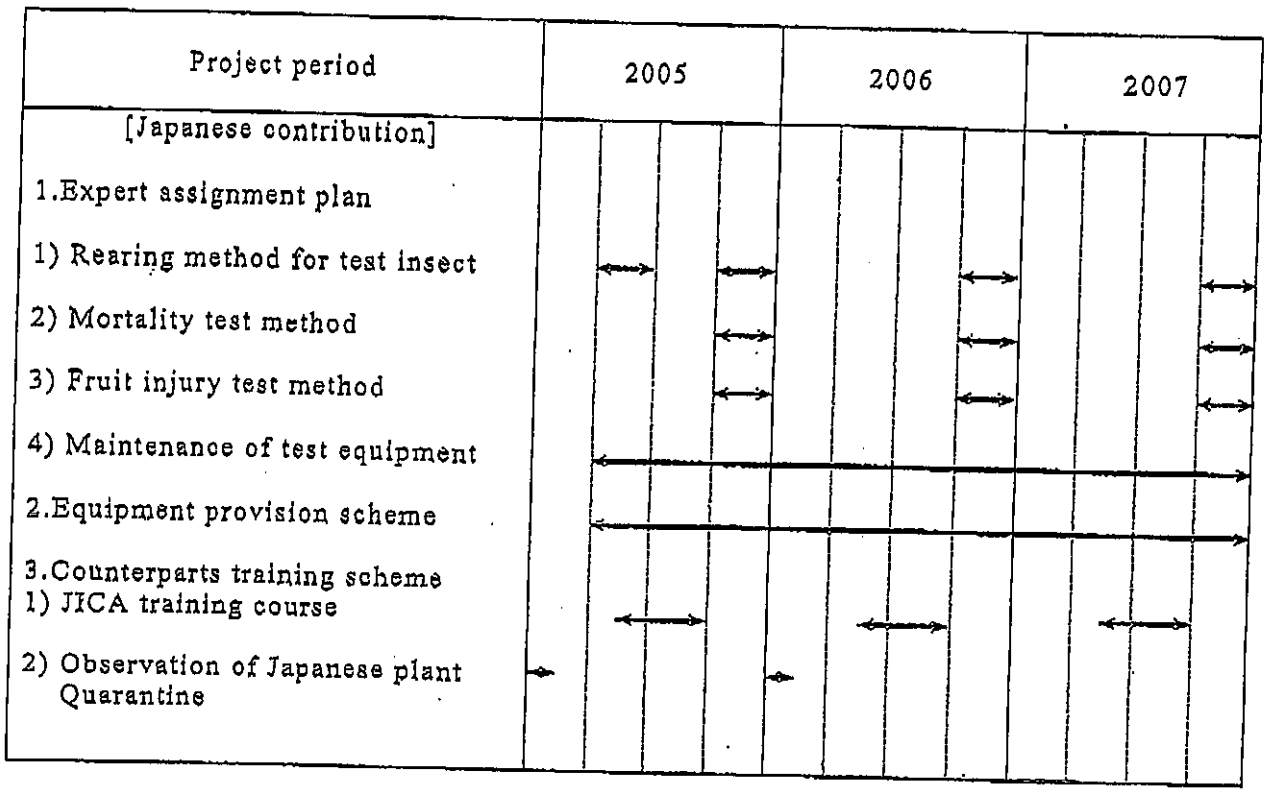
1. Annual work plan (by calendar year)



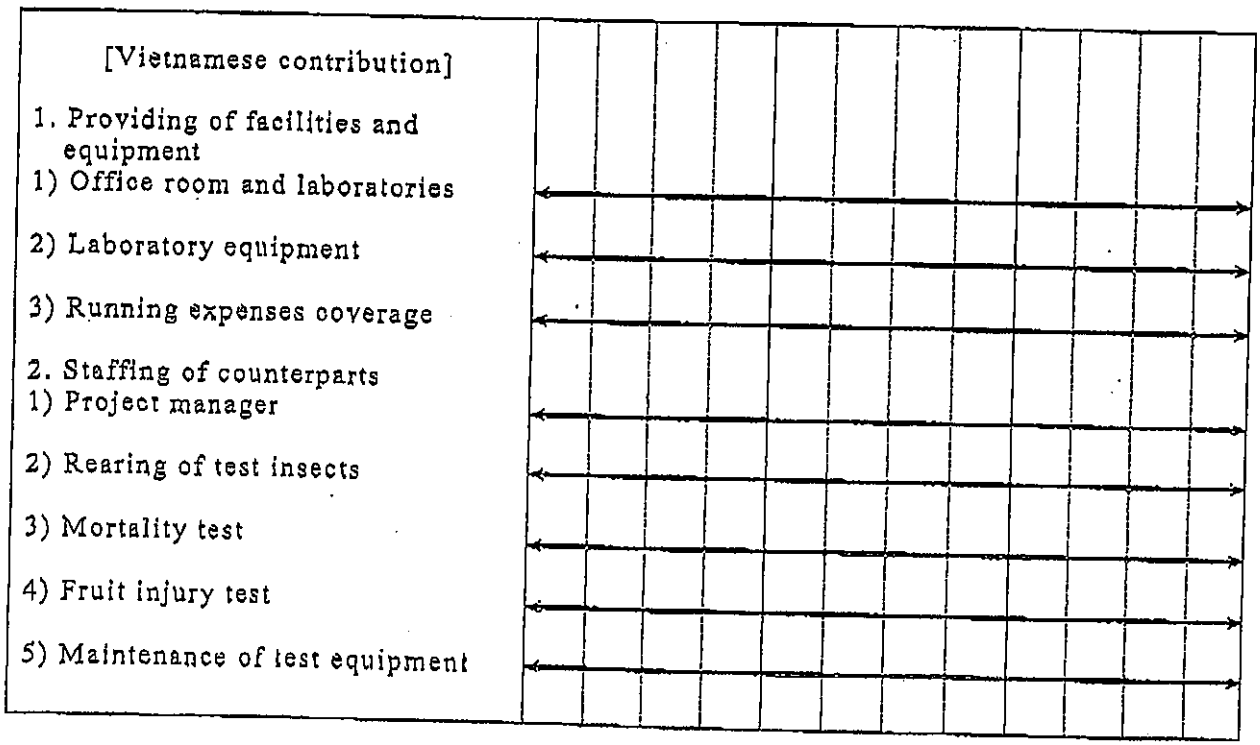
Note:

1. Target pests: B. dorsalis, B. cucurbitae, and other species of fruit flies
2. Target fruit: Dragon fruit
3. Replicated tests would be available for the test data.
4. Technical cooperation by Japanese experts would be conducted at least for three months at harvest season of dragon fruit in a year.

2. Project input by Japan



3. Project input by Vietnam



Annex 2

List of Necessary Machinery and Materials for the Disinfestation Technology Development Test

(1) For Fruit Fly Rearing

No. Description

1. Deep Freezer
   - Capacity : 400-500 Liters
   - the Range of Temp. : -30℃ 15℃
   - * For the storage of materials for diet.

2. Refrigerator
   - Capacity : 200-400 Liters
   - the Range of Temp. : -20℃ 10℃

3. Others

(2) For Observation of Morphology of the Fruit Fly

No. Description

1. Stereoscopic Microscope
   - Magnification : X6-40 (Changing magnification by zooming)

2. Cooling Light Apparatus for Microscope

3. Microscopic Camera System

4. Camera, Strobe Light and Micro Lens

5. Electronic Dry Cabinet (Desiccator)
   - * For the storage of optical instruments

(3) For Disinfestation Test and Fruit Injury Test

No. Description

1. Vapor Heat Treatment System (Testing System)
   - Size : 3110mm W x 1030mm D x 2370mm H
   - Capacity of chamber : 1 m3
   - Temperature Range : Room temperature +10-50℃
   - Temperature control amplitude: 0.1℃
   - Temperature homogeneity in the chamber : +- 0.3℃
   - Humidity Range : 55-95%RH
   - Humidity control amplitude: 0.1% RH
   - Power source : 200V, 50/60Hz, 3phases
   - With the function of program control, and Japanese manuals

2. Shower Cooling System
   Size :
   Capacity of chamber : 0.6 m3

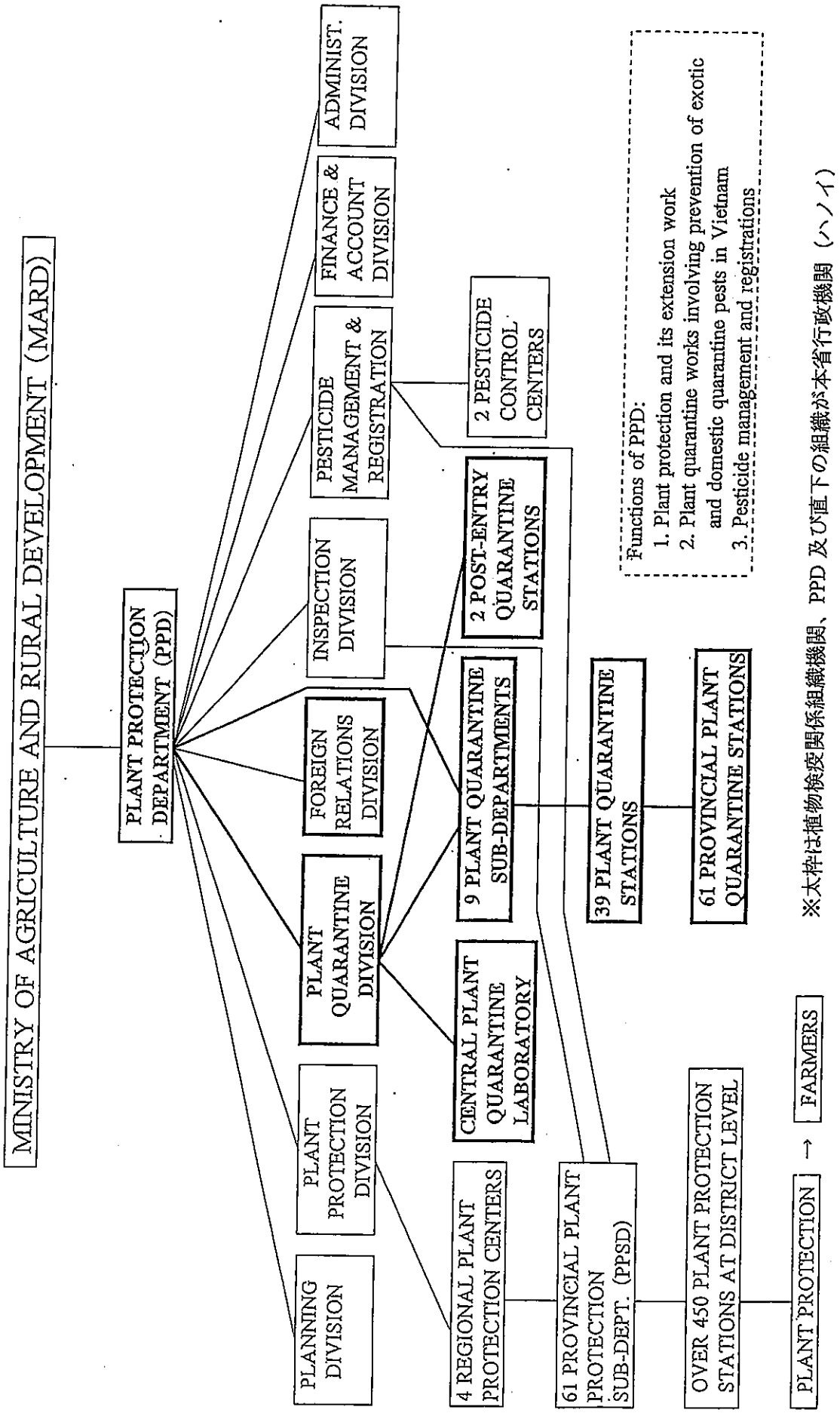
3. Temperature Sensor
   Type : Pt100Ω
   with extended reed line 10 meters

4. Personal Computer System
   Operating System : Windows XP
   * Accessary
   Printer
   Printer Cable

5. Water Bath with Electronic Thermometer
   Size : about 1,800-2,400W x 1,800-3,000D x 2,500-3,000H mm
   Range of temperature : 25-30℃

6. Temperature Control inoubetor for Fruit Storage
   Size : about 1,800-2,400W x 1,800-3,000D x 2,500-3,000H mm
   Range of temperature : 0-20℃

2．ベトナム国農業農村開発省組織図



The plan of experiment for lifting the ban of importation of mangoes

Postharvest Disinfestation of Vietnamese mangoes Using High-Temperature Forced-Air

September 2003

Plant Protection Department

Prepared by the Plant Protection Department, Ministry of Agriculture and Rural Development (MARD), Viet Nam.

CONTENTS

INTRODUCTION

Viet Nam wishes to develop its export trade in fresh horticultural produce but, as a country with Tephritid fruit flies, quarantine limitations apply. The Vietnamese Ministry of Agriculture and Rural Development (MARD) initiated contact with the Ministry of Agriculture, Fishery and Forestry of Japan to determine the technical requirements for developing a postharvest treatment to disinfest fresh produce of potentially infesting fruit flies. While a number of crops were identified, the highest priority was assigned to developing a treatment for mangoes and dragon fruit.

A list of fruit fly species occurring in Viet Nam together with those associated with the crops of export interest has been sent to Japan. Two fruit fly species, *Bactrocera dorsalis* (Hendel) and *B. cucurbitae* () are being of Japan Quarantine concerns. *B. correcta* (Bezzi) has also been found as a significant pest in association with fruit in general, in the south of Vietnam and sometimes they are found to cause a little damage related with mangoes. So all of three species have been intended to be involved in this research programme. Regarding to mango, the research programme has been divided into 5 parts:

Part 1. Supply of test insects and test fruits. Establishment of fruit fly colonies, development of a rearing management system and accessing supplies of mango fruits.

Part 2. Water Bath Tests using naked insects. Determination of the most tolerant species and life stage to high temperature following immersion in a water bath. All fruit-infesting life stages of each species were tested.

Part 3. Susceptibility Comparison Test. Determination of the most tolerant life stage to high temperature when infesting fruit.

Part 4. Small-scale Mortality Test. Determination of treatment conditions necessary to kill the most tolerant life stage in fruit.

Part 5. Confirmatory Trial. Demonstration of the efficacy of the treatment conditions necessary to kill at least 30,000 of the most tolerant life stage in fruit.

1 TEST INSECTS AND TEST FRUITS

1.1 Test insects

1.1.1 Source of wild flies

Infested fruit were gathered in the Cau Ong Lanh and Cau Muoi markets. These markets are where all fruit from South Viet Nam orchards are gathered. They are transported to the market by boat after harvesting for sorting, repacking and then forwarding to other markets. Infested fruit were also gathered from orchards in the South East area of Vietnam (Dong Nai and Binh Duong provinces). *B. dorsalis* were collected from infested custard apple, carambola and guava, *B. correcta* from infested jujube and guava. *B. cucurbitae* are being intended to be collected from infested Balsam- apple.

1.1.2 Methods of rearing and propagation

The fruit fly colonies were reared in two controlled environment rooms in the laboratories of the Southern Regional Plant Quarantine Office. The rooms had temperature and humidity control systems including air conditioners, heaters, humidifiers and a controlling system. Data loggers recorded the temperature and humidity in each rearing room.

Shelves were used for holding cages used to rear the adult, pupae and larvae. Adult rearing cages were made from aluminium with mesh on the top and the four lateral sides. Small cages (30x30x30 cm) were used for the colony establishment (first generation) and large cages (70x70x70 cm) were used for rearing subsequent generations. Larval rearing cages (70x70x50 cm) were also made from aluminium with cotton material on the top and sides.

The temperature in the rooms was maintained at 27 ± 1 ^{0}C and humidity at 70 ± 15 % RH. Natural light was provided from (2x1.5 m) windows placed on opposite sides of the (3x3x3 m) room. Artificial light was supplied by eight (1.2 m) fluorescent light tubes from $7^{h}30$ a.m - $4^{h}30$ p.m everyday. Flies had a natural dawn and dusk (table 1).

Table 1: Time for sunrise and sunset

Dawn and	Summer	Winter
Sunries	5:15am	6:30am
Sunset	6:30pm	6:00pm

Pesticide free fresh carrot was used as the basis of the larval diet. The carrots were washed, sliced, blended and mixed with torula yeast, HCl and nipagin (Table 2). The diet was divided into 800 g portions and stored in plastic bags in the refrigerator at 5^{0}C.

Table 2: Ingredients of fresh carrot diet.

- Blended fresh carrot	800 ml
- Nipagin	1.04 g
- Torula yeast	16 g
- HCl	15 ml

The adult flies were supplied with sugar, yeast hydrolysate and water. Sugar was provided separately on a tray. The yeast was mixed with sugar in a ratio of 3:1. The water was provided in a box with a sponge wick or an upturned jar on filter paper.

Eggs were collected from adult flies using an artificial egging device. Holes were made in a plastic cup with a sealed lid. Orange juice was smeared on the inside of the cup. A piece of saturated wettex was also placed in the bottom of the cup to maintain high humidity. The cup was placed in the cage for 24 hours to collect eggs.

The eggs were washed from the cup into a beaker containing water. The eggs were allowed to settle and the water was decanted off. The eggs remained in the beaker in a egg-water slurry until needed. Five 0.1 ml aliquots were syringed onto black filter paper and the number of eggs was counted in each sample. For *B. dorsalis* the number of eggs per ml was calculated at about 8000 eggs / ml. A simultaneous experiment showed that 1g of carrot media was needed for three larvae to develop completely from the eggs to pupae. Therefore 2400 *B. dorsalis* eggs were seeded onto each plate of 800 g of carrot diet, which was 0.3 ml of the egg-water slurry.

These diet plates were held in plastic boxes or in special larvae cages. Moist sand was spread in the bottom as a pupation medium. The boxes or cages had lids or side walls made of cotton cloth to provide ventilation for the larvae to develop, but were sealed so that the larvae could not escape. At the end of the third instar, the larvae jumped out of the diet and onto the pupation media. The sand was sieved top recover pupae 10 - 11 days after egg collection. Pupae were weighed, counted and placed on shallow trays with moistened sand and put in adult cages for emergence.

Good hygiene was maintained in the laboratory at all times. Water bowls were placed under the legs of all shelves to exclude ants. A McPhail trap containing fruit juice with a little detergent was used to control *Drosophila sp.* Every day, the room was cleaned. Any dead insects or other residue were removed from the floor of the room. Laboratory equipment including artificial domes and adult cages were washed carefully and used immediately afterwards.

1.1.3 Quality control parameters

Egg hatch:

Egg hatch was calculated every generation. Three samples of 100 eggs were taken from the eggs collected for culturing. The eggs were placed onto moist black filter paper on larval diet in a Petri dish. The lid was put on the Petri dish to maintain high humidity. The Petri dish was placed inside a plastic box with a ventilated lid. The box was held at

optimum temperature (28 ^{0}C) in the incubator. The number of unhatched eggs was counted after 72h to determine the % egg hatch.

Pupation:

The three Petri dishes used to determine egg hatch, with lids removed, were placed back into the plastic box with moist sand as a pupae medium and held in the rearing room. The pupation media was sieved 10 - 11 days after egg collection to collect the pupae. The media was checked to ensure that there were no larvae or pupae remaining and the % pupation recorded.

Adult emergence, gender ratio:

Pupae, which had been used to determine % pupation, were kept in a ventilated box in the rearing room. The pupation medium was remoistened as needed. The flies were allowed to emerge. When they were dead the number of males and females were counted to determine % emergence and gender ratio.

Pupae weight:

A total of 500 pupae were taken from the main culture on the day of sieving and weighed and recorded.

Flight ability:

One hundred pupae were taken from the main culture to determine flight ability. A test unit (Boller 1981) consisting of a plastic Petri dish holding the pupae and a cardboard tube of 100 cm height was use. The tube was fitted into the Petri dish and was painted inside vertically with FLOUN-AD-1 (or talcum powder) that prevented crawling flies from moving up the wall and escaping. Drying paper was placed into the tube to provide more surface area. Each tube was used 3 - 5 times.

One hundred pupae were put into each unit one day before they began emerge and the test was terminated after 10 days. Parameters recorded and method of calculation is shown in Table 3.

Table 3: Calculation of the Flight Ability Index (FAI)

$FAI = \frac{\text{Number of flies left by flight (A)}}{\text{Total number of flies emerged (A+B+C)}}$
Where: A : Number of flies that have left the unit by flight B: Number of remaining flies that appeared to be normal C: Number of remaining flies that were obviously deformed

All the above quality control parameters were measured for both species and have been demonstrated to be relatively stable throughout the generations reared under laboratory conditions.

1.1.4 Other parameters determined for the colony

Fecundity was measured by placing 20 males and 20 females (newly emerged adults) into a small cage. They were provided with sugar, water and yeast hydrolysate daily. Eggs were collected using a collection cup for each 24 h period and counted daily until adults were all dead.

Fertility was also measured by placing 20 males and 20 females (newly emerged adults) into a small cage. They were provided with sugar, water and yeast hydrolysate. Eggs were collected at the same time each day, for 1 h, until all adults were dead. The eggs were placed on black filter paper on moist sponge, counted and held in the incubator at 28 ^{0}C. After 72 h, the number of unhatched eggs was counted and the number of hatched eggs calculated.

1.1.5 Duration of each developmental stage

Eggs:

Eggs were collected for a maximum of 1 h duration. One hundred eggs were placed on pieces of black filter paper laid on the top of a piece of wet sponge in a Petri dish with lid. The Petri dishes were held at constant temperature in an incubator (28 ± 0.5^{0}C). The lid on the Petri dish ensured that the microclimate around the eggs on the wet sponge was maintained at high RH. The number of unhatched eggs was counted every 30 minutes until the time when hatching was completed. The time when 50% of the eggs had hatched was calculated. This was considered as the point of 100% embryonic development for the population. Three replications were completed. The result showed that 100% embryo development was at about 36.5 h for *B. dorsalis* and 34.6 h for *B. correcta* .

Each larval stage:

Eggs were collected for a maximum of 1 h duration. The eggs were washed through a Buchner funnel under mild suction onto black filter paper. Pieces of filter paper were cut out so that there were exactly 100 eggs per piece. Each piece of filter paper was placed into a Petri dish containing fresh carrot diet and then held in an incubator at 28 ± 0.5 ^{0}C. The number of eggs that had hatched 72 h after collection was counted. Every 2 h one Petri dish was destructively sampled to determine the number of larvae of each instar. Three larval instars occur which are distinguished based on their mouth hooks (Anderson 1963).

1.2 Test fruits

1.2.1 Mango supply

Mango fruits were harvested from Dong Thap Province. Orchards for fruit harvesting are 60,000 square meters in area and separated 5 kilometres from each other. All fruits were covered by cloth bags when they reached 2 to 3 cm in length. No pesticides were applied on fruit supplied for experimental purposes. The harvest period was from late February until May.

1.2.2 Features of test mango

The Cat Chu variety of mango (Mangifera indica L . – Dicotyledonae : Anacardiaceae) was used in all tests. Fruit weight for testing: 210-370 g for Susceptibility Comparison Tests; 213-267 g for Small-scale Mortality Tests and 267-410 g for the Confirmatory Trial. The average fruit size (length x width) was 13 - 15.3 cm x 7.1 - 8.2 cm. Only mature green fruits inside undamaged bags were harvested. The stems were cut and the fruit, still individually bagged, were transported to the laboratory in bamboo crates. Each crate contained about 200 fruit and was lined with paper.

The Cat Chu variety of mango is commonly grown in Dong Thap province. It has good growth capacity, easy blooming and fruiting, and very high yielding (about 400 kg of fruit/8-year-old tree/year). Fruit is rather round in shape with average weight of 300-350 g. Peel is green in young fruit and turns to dark yellow in ripe fruit. The flesh of ripe fruit is yellow and sourish sweet (18% in Brix). The flesh to seed and peel weight ratio is high (78%) (information from Southern Fruit Research Institute).

1.2.3 Postharvest handling

Fruits were harvested from 12:00 to 2:00 pm then were transported to the laboratory by road and reached Ho Chi Minh City at 7:00 p.m. They were stored in a controlled environment room with the temperature and relative humidity of 28°C and 70-75%, respectively.

Within 24 h of harvest the fruits were treated with fungicides to prevent the development of postharvest rots. The fruits (with their stems removed) were placed into a net basket, then immersed in 1ml/l Cadazim500FL solution for 5 min at 52°C. This was followed by a 30 s dip in Octave 50WP (0.55ml/l) at ambient temperature. Fruits were spread on the floor until completely dry.

All mango fruit was individually weighed and sorted into replicates based on their weights. The fruit were placed into cardboard boxes (10 - 12 fruits per each), and then either used immediately or held in cold storage (9 - 10°C and 25 - 30% RH) until they were required. For the Susceptibility Comparison Tests, fruits were kept in cold storage for 18, 25 and 31 days for replicates 1, 2 and 3, respectively. For the Small-scale Mortality Tests the fruit was not held in cold storage, as fruits were used just after harvesting. For the Confirmatory Trial the fruits were kept in cold storage for 17, 26 and 32 days for replicates 1, 2 and 3, respectively.

1.2.4 Production and distribution

Cat Chu variety has been commonly grown in many provinces belonging to Mekong River Delta such as Dong Thap, Tien Giang, Vinh Long, Can Tho, and some provinces belonging to North East of South Vietnam. The harvesting date of Cat Chu mango is generally from the beginning of March to the end of May. Other mango varieties including Thom, Hoaloc, Buoi, Hon and Thanh Ca are also grown but in smaller quantities.

The harvesting date of Thom mango is from February to the end of April; and Hoaloc, Buoi, Hon, Thanh Ca from the beginning of March to the end of May. According to the MARD Extension Department, the area and the production of mango from 1996 to 2000 are shown in the Table 4. The distribution chain for mango in Vietnam is shown in Table 5.

Table 4: Production of mango varieties.

A. All varieties

Year	1996	1997	1998	1999	2000
Grown area (ha)	25,000	26,000	26,000	27,000	28,000
Production (tons)	380,000	300,000	375,000	320,000	392,000

B. Cat Chu variety

Year	1996	1997	1998	1999	2000
Grown area (ha)	5,000	5,000	5,000	5,000	5,500
Production (tons)	95,000	82,000	90,000	80,000	100,000

Table 5: Distribution chain for mango in Vietnam

Mango → (From orchards)	Merchants →	Fruit → Granary	Whole sale market	C_2H_4 treatment	Shelf-life
In the morning	At noon	In the afternoon	Early next morning	24-48 hours	28°C:10 days 10°C:60 days

1.2.5 Registered pesticides

The pesticides registered for use on mango in Vietnam are shown in Table 6.

Table 6: The pesticides registered for use on mango in Vietnam

No.	Insecticides	Target insect for control					
		Mango hopper	Mango moth	Rose beetle	Leaf weevil	Thrips	Mealy bug
01	Butyl 10WP	X					
02	Syrux 25EC		X	X	X		
03	SumiAlpha 5EC		X	X	X		
04	Sumicidin 20EC		X	X	X		
05	Polytrin P440ND	X	X	X	X	X	
06	Bi58ND		X	X			
07	Supracide 40ND			X		X	X
08	Monitor 72ND		X	X	X		
09	Basudin 50ND		X	X			
10	Fenbis 25EC		X	X	X		
11	Sherpa 25EC	X	X	X			
12	Admire 50EC	X		X			

The crop is sprayed 4 – 6 times per season.

2. WATER BATH EXPERIMENTS

2.1 Materials and methods

All experiments were carried out at the Plant Quarantine Zone II of the Plant Protection Department, Ho Chi Minh city using laboratory colonies established July-August 2000. Heat treatment evaluations for *B. dorsalis* were conducted during November 2000 to January 2001 and *B. correcta* during November 2000 to July 2001. The colonies were therefore less than one year old when used for water bath experiments.

Heat treatment evaluations for *B.cucurbitae* will be conducted after having colonies established.

2.1.1 Insects

Laboratory colonies of each fruit fly species were reared on a carrot diet using methods described in Part 1. Eggs were collected from the adult females over a 1-3 h period and then either heat treated immediately (<4-h-old, "young eggs"), or held for 23 h in a photoperiod of 12:12 (L:D) at 28 ± 1.0 • C for treatment as "mature eggs" (<24-h-old). Tests were also conducted on first, second and third instars for both species (approximately 2, 3 and 5 d after egg laying, respectively). The developmental stages of larvae were confirmed before each heat treatment test as described by Elson-Harris (1988).

2.1.2 Heat treatment

Glass tubes were used to contain the insects during hot water immersion. Fine muslin was secured to each end of each tube to keep eggs or larvae in the tube while facilitating rapid water movement through the tube. Treatments were conducted in a Thermoline water bath (Model NWB1-50) with a capacity of 32 litre (filled 4 cm from top) and internal dimensions of 75 x 40 x 40 cm. Heating was provided by a Unistat 130 immersion heater (temperature accuracy ± 0.01 • C). The target temperature was checked at the start of each test using a calibrated reference thermometer (Zeal, England) calibrated by the Bureau of Sugar Experimental Stations laboratory at Indooroopilly, Australia. The calibration is endorsed by the National Association of Testing Authorities, Australia (NATA).

Eggs were counted onto moist filter paper before treatment and then moved by irrigating them off the paper into the tubes. First instars were selected from batches of hatching eggs, counted onto filter paper and moved by irrigation into the glass tubes. Second and third instars were sieved from the larval diet using water to disperse the diet leaving the larvae exposed for collection and counting directly into treatment tubes. The number of insects per tube varied depending on the life stage. Approximately, 100 eggs and first instars and approximately 50 second and third instars were placed into each tube. Two tubes were similarly prepared for non-treated controls for each life stage.

Eight time exposures were used in order to obtain a range of mortalities for statistical analyses. Each test consisted of one species and life stage tested at 46 • C. Eight treatment tubes were simultaneously immersed at the start of each test. Immediately following the target immersion time (1 minute to 8 minutes), individual tubes were removed from the hot water bath, drained and immersed in 25 ± 0.5 • C water for one min. Control insects for each time x temperature regime were immersed in 25 ± 0.5 • C water for a period that exceeded the longest hot water immersion duration of that test by one min. Approximately 200 eggs and first instars or 100 second or third instars were used as controls. Three replicate tests were completed for each life stage and species. A total of 30 tests, 15 each for *B. dorsalis* and *B. correcta,* were conducted. And 15 other tests for *B.cucurbitae* will be also conducted.

2.1.3 Mortality assessment

Following immersion in 25 ± 1.0 • C water, treated eggs and larvae were placed on diet and held at 28 ± 1.0 • C until pupae formed. The pupae were sieved from the pupal medium and normally-formed pupae were counted as live.

2.1.4 Statistical analyses

Analyses of observed mortality at each temperature used the model:

$$\log(-\log(1-p)) = a+bt,$$

where p is the expected observed mortality, and t is time in minutes (Preisler and Robertson 1989). This gave approximate linearity. The estimated time for 90, 95 and 99% mortality (LT_{90}, LT_{95} and LT_{99}), which relates to mortality after there has been allowance for control mortality, was calculated to give an expected mortality for 99% kill of $c+(1-c)0.99$, where c was the control mortality. Other mortality levels were similarly calculated for 90 and 95%. Comparison of species and life stages was made using confidence intervals calculated so that non-overlap was equivalent to a statistically significant difference in a Student t-test at the 1% level.

The model was fitted using a robust version of the generalised linear model analysis available in S-PLUS (Statistical Sciences Inc. 1991) that assumes any variance is proportional to that of a binomial distribution. The robust version of the model fitting procedure used, which reduces the weight given to points that lie away from the main body of the data. This effectively handled the variability in response, with occasional large outliers that are evident in the plots of mortality *versus* time of exposure. In one instance where the life stage was particularly susceptible an LT estimate could not be calculated because too few data points <100% were observed. This data set was excluded from the calculation of mean and confidence intervals for the life stage concerned.

3. SUSCEPTIBILITY COMPARISON TEST

3.1 Design

As a species *B. dorsalis* is recognised as one of the more economically significant fruit fly species because of its wide host range. In order to evaluate this important species further, a Susceptibility Comparison Test was conducted to compare the heat tolerance of all immature stages of *B. dorsalis* in Cat Chu mango. Young egg, mature egg, first, second and third instars were compared. For each stage we treated 4 fruit, each initially infested with 80 eggs, at each of 6 fruit core target temperatures 42, 43, 44, 45, 46 and 47^{0}C. The fruits were treated in a heat treatment machine in 4 crates. A complete randomised block design was used to place fruit into the crates. Each crate contained 1 fruit for each temperature from each life stage.

If there is a further requirement by MAFF of Japan , other Susceptibility Comparison Tests will be conducted in the same process for *B. cucurbitae* or *B. correcta* in cat Chu mango.

3.2 Preparation methods for infested fruits

3.2.1 Preparation of fruits

The fruit used in the susceptibility comparison tests weighed 210-370 g (harvesting date: 28/02/2001). Each piece of fruit was weighed and the weight written on the peel. A table of the frequency distribution of each weight class was used to select fruit to ensure that the weight range in each replicate was kept as narrow as possible. The weight range was 282 – 315 g for replicate 1, 320 – 360 g for replicate 2 and 209 – 248 g for replicate 3. We used a randomised complete block to assign fruit for infestation of each life stage then we randomly assigned fruit to each dose (i.e. a pre-determined target core temperature).

3.2.2 Pest infestation methods

Artificial inoculation was used for the Susceptibility Comparison Tests. Eggs were collected and infested on a different day for each life stage (young egg, mature egg, 1st instar, 2nd instar and 3rd instar) based on the development rate.

Eggs were collected in a collection cup rinsed in fruit juice, from cages of fruit fly adults at optimum fertility and fecundity. The collection cup was placed in the cage for 1 h 30 min to collect adequate numbers of eggs. The eggs were washed from the collection cup onto black filter paper in a buchner funnel under mild suction. The black filter paper was cut into squares each holding 80 eggs. The eggs were held for about 24 hours on saturated sponge in an incubator (at 28 ^{0}C) until ready for infestation. The infested mangoes were held in the fruit holding room at a constant temperature (28 ± 0.5^{0}C) to allow the eggs to develop through to the required instars.

3.2.3 Number of replications

In aiming to minimise fruit weight affects by grouping fruit of similar weigh for each run, the treatments are not strictly replicates. We assume that the time taken to reach the target treatment conditions, though different for the different weight ranges, did not influence the relative susceptibility of the life stages. For our purposes the three runs conducted are considered replicates.

3.2.4 Number of the test fruit

The number of control and treated fruit of each replicate is given in Table 7.

Table 7: The number of control and treated fruit for each replication .

Life Stage	Number of Control fruit	Number of fruit per treatment	Number of treatments	Total number of treatment fruit
YE	4	4	6	24
ME	4	4	6	24
L1	4	4	6	24
L2	4	4	6	24
L3	4	4	6	24
Total	20	20	30	120

3.2.5 Age composition in the fruit on the test day (instar checks)

Extra fruits were infested for each stage and used to ensure that the insects were at the correct life stage during treatment. At the time of treatment the fruits were dissected and the proportion of each stage present was calculated .

3.3 Vapour heat treatment device

The vapour heat treatment device was located in the laboratories of the Plant Quarantine office zone II (28 Mac Dinh Chi St, District No 1, Ho Chi Minh City, Vietnam). All experiments conducted in fruit were completed in the unit at this location.

3.3.1 Structure and size

The vapour heat treatment chamber was designed by the Queensland Horticulture Institute (QHI) of the Department of Primary Industries, Queensland Australia. It consists of a chamber, a control system that uses software operated from a personal computer, and a standard printer. QHI designed and built the control system using SCADA software and fitted this to the chamber which was built in Vietnam by the University of Agriculture and Forestry to QHI's design specification.

The insulated chamber has external and internal sheeting of stainless steel. Access is provided by one door at the front of the chamber. The internal dimensions of the chamber are 700 X 600 x 720 mm. A second door at the front allows access to the heater and water cooling system (spray nozzle fittings).

The standard container for holding the product being treated is a plastic crate 390 X 550 X 150 mm high. These crates can be stacked 5 high although typically we used 4 crates for our experiments. Each crate has ventilation slots in the base.

3.3.2 Heating method and humidity control

Air at the required temperature and relative humidity is circulated by centrifugal fan, producing an average linear velocity through the product bed of 1.4 m/sec.

Heating is derived from an electrical heating coil while a water spray upstream from the heating coil provides humidification.

Equipment control is performed by a supervising SCADA software system.

3.3.3 Measurement of temperature and humidity

Temperature and relative humidity are measured using a high precision multi-channel temperature-measuring module. Data from the temperature module is delivered to a control computer by RS 485 serial interface.

All measurement and control was supervised by standard SCADA software incorporating routines produced by the QHI developers specifically for this task. All measurement parameters were displayed directly on the operator screen and updated continuously.

All temperature probes were calibrated when the chamber was installed. The temperature measurement unit returns a reading to the controlling computer which incorporates all of the deviations of the amplifier, individual probes and other circuitry. A higher level of calibration accuracy is achieved by applying a first-order transformation determined by measurement over at least 4 temperatures and submitting to regression analysis. Slope and offset parameters are applied for each channel. Using this technique, an accuracy of better than ± 0.1 °C is achieved. The parameters can be displayed or printed for audit purposes.

Routine temperature probe calibration adjustment was carried out at one measurement point only (typically the treatment temperature), by stabilising the probes at that temperature in a water bath, entering that temperature into the computer and initiating an automatic adjustment of the displayed value by adding or subtracting an amount necessary to bring that channel to the correct reading. This adjustment is limited to < ± 1.5 °C. The new parameter is displayed on the screen and can be printed for audit purposes.

Probe calibration and 30 minute probe stability printed reports are available.

Relative humidity is measured using wet and dry bulb temperature measurement using a standard equation, although no correction is made for atmospheric pressure.

Up to 5 fruit pulp probes are available for insertion in the fruit being treated.

3.4 Chamber specifications

3.4.1 Air velocity and temperature range

Air velocity (mean) of 1.4 m/sec across the product.
Temperature range : ambient – 50 • C (heating)

3.4.2 Fruit temperature probes

Shaft : Stainless steel, 150 mm X 3 mm dia., alumina powder filled
Handle : Plastic
Lead wire configuration : 3 wire
Country of manufacture : Vietnam (from components supplied from Australia but manufactured in Japan)

Sensor detector element : Platinum resistance temperature detector (RTD)

Sensor specification : DIN 60751 (IEC 751) Class A
Temperature coefficient : 3850 ppm / °K
Country of manufacture : Japan
Active element size : 2.2 mm X 2.3 mm
Initial (uncalibrated) tolerance : +/- 0.15 °C at 0 °C (Class A)

3.4.3 Temperature amplifier

Type : 8 channel amplifier
Manufacturer : National Instruments
Initial channel matching : 0.10 °C before calibration
Data output : serial data to computer
Serial data interface : RS485
Country of manufacture : USA

3.4.4 Temperature measurement calibration

Overall accuracy for each probe after calibration is better than ±0.1 °C

At installation additional accuracy was provided for each temperature measurement channel by application of a linear transformation derived over the range of 0-50°C (parameters printed/displayed on demand) as follows:

$$T_y = AT_x + B$$

where T_y = actual temperature , T_x = probe unadjusted temperature, A and B are constants for each probe.

Routine adjustment by adjusting B value. B value is limited to ±1.5 °C.

3.4.5 Relative humidity

Measured by wet and dry bulb. Calculated by standard formula. No compensation is applied for atmospheric pressure effects. Calculated and displayed precision of ± 0.1%

Relative humidity accuracy was dependent on the temperature measurement accuracy (±0.1 °C). Estimated RH accuracy was ± 1.1% based on worst-case combinations of wet bulb and dry bulb measurements. Actual measurement accuracy of calibrated probes will be better than the worst case with resulting higher accuracy of calculated relative humidity.

3.4.6 Estimation of accuracy of relative humidity measurement

This estimation was based on the assumption that measured temperature accuracy was equivalent to the actual temperature ± 0.1 °C

Therefore at true measured temperatures as follows:

Dry bulb	47.0 °C
Wet bulb	45.2 °C
RH	90.0 %

Estimated range (using temperatures within the accuracy range of ± 0.1 °C)

Dry bulb	47.1	47.1	46.9	46.9
Wet bulb	45.3	45,1	45.1	45.3
RH	90.0	89.0*	90.0	91.1*

* Worst case limits.89.0 – 91.1 %.

3.5 Locations for temperature and humidity measurement

Fruit was placed into the heat chamber in 4 plastic crates. A diagram showing the location of the temperature sensors and the weight of probe fruit will be presented in the final report.

3.6 Treatment conditions

The treatment consisted of heating the chamber air from 30 to 47 ^{0}C over 1 h then holding at 47 ^{0}C. After the ramp phase, humidity was at 36 - 50% RH throughout the treatment. Fruit were heated in this environment and fruit for each temperature were removed when their core temperatures reached 42, 43, 44, 45, 46 and 47^{0}C. Internal fruit temperatures were monitored via the visual display on the computer screen, with the logger printing temperature records every 5 minutes. When all probe fruit reached the target temperature on the visual display, the doors on the chamber were opened and fruit were removed. Heating was then continued until the probe fruit reached the next temperature at which time further fruit were removed. When fruit were removed from the chamber they were immediately cooled under a shower of water at ambient temperature 27 - 29 ^{0}C. Cooling with water continued until the fruit core temperature dropped to less than 35^{0}C.

3.7 Storage of fruit after treatment

After treatment a slit was made in the bottom side of the fruit to facilitate drainage. Fruits were put on mesh covered drip trays on pupation medium (sand) inside large plastic boxes. The fruit was held in the fruit holding room at 28 ± 0.5 ^{0}C. Pupation medium was sieved

10 and 18 days after egg collection. Pupae were collected, counted and held in plastic boxes with moist pupation medium to allow adult eclosion.

3.8 Data analysis

The number of apparently normal pupae surviving in each control and treated fruit was recorded . The mortality at each dose was corrected for control mortality using Abbott's formula (Finney 1971) and the effective number treated at each dose was calculated.

The data were fitted to each of the probit, logit and complementary log–log (CLL) models with and without log transformation using the computer program GenStat.

The outputs from the regressions of best fit lines were compared to determine which model provided the best fit for the data.

4. SMALL-SCALE MORTALITY TEST

4.1 Design

Experiments which determined that mature eggs are the most tolerant stage, included all life stages and so contained only a few hundred insects of each stage at each point. This Small-scale Mortality Test aimed to further develop a relationship between mortality and heat treatment for this most tolerant life stage of *B. dorsalis*. Mature eggs, infested in mangoes, were heated until the fruit core reached 46.5 ^{0}C and then held for 6 different times. For each holding time there were 17 - 21 treatment fruit and 5 control fruit.

4.2 Preparation methods for infested fruits

4.2.1 Preparation of fruits

The fruit used in the Small-scale Mortality Test weighed 213-267 g. Each piece of fruit was weighed, and the weight written on the peel. Fruit used in the experiment were weighed and then selected to ensure that the weight range was kept as narrow as possible. We used a randomised complete block to assign fruit to each dose (i.e. specified time exposure at 46.5 ^{0}C).

4.2.2 Natural infestation method

Each piece of fruit was pinholed 20 times with an entomological pin on the flat side on which the weight was written. Fruits were placed in cages containing gravid females, in rows parallel to the light source with the pinholes facing upwards. The fruit remained in the cage for 15 minutes. Each cage held 18,000 adults of *B. dorsalis*. There were 5 rows each containing 5 fruits. One fruit from each row was randomly chosen as a control fruit.

The fruit was removed from the cage after first carefully removing the flies by gently brushing or blowing on the fruit. The fruit from each cage was kept separately. The control fruit was used to estimate the number of insects in the treatment fruit from that cage. Extra fruits were infested for instar checks. The fruit was held at 28 ^{0}C and treated when the insects reached the most tolerant stage (mature egg).

4.3 Replication

Only one replication was completed .

4.4 Number of test fruit and total weight

The number of control and treated fruit is shown in Table 7.

Table 7: The number of control and treated fruit for the Small-scale Mortality Test.

Treatment time at 46.5 ^{0}C (minutes)	Treated fruits	Control fruits	Total Fruits
0	20	5	25
5	20	5	25
10	20	5	25
20	20	5	25
30	20	5	25
40	20	5	25
Total	120	30	150

4.5 Age composition in the fruit of the test day

To have mature eggs in the fruit on the test day , fruit were held at 28^{0}C in the fruit holding room for 24 h 4 min after egg inoculation.

4.6 Placing and loading fruits in the vapour heat treatment chamber

As for the Susceptibility Comparison Test, fruit was placed into the heat chamber in 4 plastic crates. The total number of fruit was 120 with a total weight of treated fruit recorded. The diagram showing the location of the temperature sensors and the weight of probe fruit is attached .

4.7 Treatment conditions

The treatment consisted of heating the chamber air from 30 to 47.5^{0}C over 30 min then holding at 47.5^{0}C. Humidity stabilised at ~50%RH. The internal temperatures of the probe fruit were monitored via the visual display on the computer screen, with the logger printing temperature records every 1 minute. Fruit were heated until the core temperature of 3 of the 5 probe fruit (more than 50% of probes) reached 46.5^{0}C. Then the doors were opened and the first batch of fruit were removed. The timer was started and further batches of fruit were removed after 5, 10, 20, 30, 40 min. The chamber was opened to remove the fruit for each treatment duration, and re-closed as quickly as possible to minimise disruption to the treatment conditions. During the 40 minute hold time the core

temperature was kept at a minimum of 46.5^{0}C. When the last fruits were removed, the heater and the humidifier were stopped and the run terminated. When fruit were removed from the chamber they were immediately cooled under a shower of water at ambient temperature 27-29^{0}C. Cooling continued until the fruit core temperature dropped to less than 35^{0}C.

4.8 Storage of fruit after treatment

After treatment the fruit were held at 28 ± 0.5^{0}C and pupae recovered as described for the Susceptibility Comparison Test .

5. CONFIRMATORY TRIALS

In the final part of this study Confirmatory Trials were conducted to demonstrate the efficacy of the chosen dose when used to kill at least 30,000 of the most tolerant life stage in fruit, thus demonstrating a high level of quarantine security. The methods used in the Confirmatory Trials were similar to those used in the Small-scale Mortality Test.

As mentioned in Susceptibility Comparison Test part, if there is a requirement from MAFF of Japan, other Confirmatory Trials will be conducted to demonstrate the efficacy of chosen dose when used to kill *B.cucurbitae* or *B. correcta*.

5.1 Design

As a dose response curve was unable to be generated from the results of the Small-scale Mortality Test, the confirmatory dose was based on the empirical data together with treatments developed by other researchers for disinfesting mangos. In the Confirmatory Trials Cat Chu mangoes were treated with a dose, reaching a core fruit temperature of 46.5°C which was held for 20 min. All the treatment fruit was placed in the machine and treated at the one dose (i.e. treatment x time combination).

5.2 Preparation methods for infested fruits

5.2.1 Preparation of fruits

The fruits used in the Confirmatory Trial weighed from 200 to 400 g, for 3 replicates , respectively. Each fruit was weighed and assigned to one of 4 crates.

5.2.2 Natural infestation method

Infestation methods were identical to those described for Small-scale Mortality Test.

5.3 Number of replication

Three replications were completed.

5.4 Number of test fruit

The number of control and treated fruit is shown for replication 1, 2 and 3 in Table 8.

Table 8: The number of control and treated fruit and their weight for confirmatory trials

Replicate	Treated fruits	Control fruits	Total fruits
I	115	29	145
II	115	29	145
III	115	29	145

5.5 Age composition in the fruit on the test day

To have target stage of fly on the fruit of the test day fruit were held at 28^{0}C in the fruit holding room for required time .The proportion of each stage present at the time of treatment in each of three fruits prepared for each replicate must be recorded.

5.6 Placing and loading fruits in the vapour heat treatment chamber

Fruit was placed into the heat chamber as described in the Small-scale Mortality Test. Diagrams showing the location of the temperature sensors and the weight of probe fruit, temperature and humidity records from the unit chart recorder will be attached .

5.7 Treatment conditions

The treatment consisted of heating the chamber air from 30 to 47.5^{0}C over 30 min then holding at 47.5^{0}C. Humidity stabilised at ~50%RH. The internal temperatures of the probe fruit were monitored via the visual display on the computer screen, with the logger printing temperature records every 1min. Fruit were heated until the core temperature of 3 of the 5 probe fruit (more than 50% of probes) reached 46.5^{0}C. Then the timer was started and the fruit was held at a core temperature of 46.5^{0}C for 20 min. When the exposure time required was reached , the fruit were automatically cooled under a shower system of water at ambient temperature 27 - 29^{0}C. This shower system was availably installed inside the chamber just for cooling in the Confirmatory Trials. The fruit in this test did not need to be

removed out for cooling as in the previous mortality tests. Cooling continued until the fruit core temperature dropped to less than 35^{0}C.

5.8 Storage of infested fruit

After treatment the fruit were held at 28 ± 0.5 0^{0}C and pupae recovered as described for the Susceptibility Comparison Test and Small-scale Mortality Test.

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4．ベトナム国におけるミバエ類の発生調査報告書

INTRODUCTION

1. Project background

The Government of Vietnam has allocated high priority to the agenda of poverty alleviation, food security, gender equality and a sustainable environment. Emphasis has been placed on the rural population, which makes up 70% of the country's total population of 77 million. Agricultural diversification, particularly in horticulture and fruit production, has been identified as one means to increase food availability and the income of farmers. The Government has liberalized land use policies to facilitate the expansion of fruit and vegetable production.

The area currently under fruit production is estimated to be approximately 346 000 ha, with the southern area of Vietnam producing 80% of the total production. Production in the Mekong Delta represents about 66% of the national figure. The current value from fruit production is about $US 282 million per year, an average annual return of $US 815 per ha. Depending on the fruit type and production area, this represents a 2- 6 times better return per ha than that of irrigated rice, as well as being less labour intensive. The Government, with assistance from overseas donors, aims to increase the area of fruit production form 346 000 ha to 1 million ha by 2010.

A wide range of pests and diseases may reduce fruit and vegetable production in quantity and quality. The insect pest control measures in use are based almost exclusively on the application of broad- spectrum insecticides used as a regular prophylactic treatment. Field evidence world- wide shows that this approach induces many serious pest problems, such as those caused by mites, aphids, scales and leaf miners, because of its deleterious effects on the natural enemies of pests. Therefore cost- effective, sustainable and environmentally acceptable pest management practices must be developed and introduced, based on Integrated Pest Management (IPM) principles. Considerable progress has been made with the development and implementation of IPM in vegetables but IPM in fruits is still underdeveloped.

It is impossible to tackle all the pest and disease problems of fruit production at once because of their complexity and interrelation, As a result, IPM in fruit production should start by developing and introducing management practices for a single pest problem that is great interest to farmers. Once satisfactory results have been achieved, IPM activities should be extended to the management of other pest problems.

One of the most serious pests is the fruit fly (Tephritidae). This is great concern to farmers, as it causes substantial losses in quantity and quality. In the Mekong Delta, for example, up to 100% of guava can become infested while, in northern Vietnam, very high levels of damage (70-100%0 are inflicted on peach crops in June- July. Fruit fly

infestation to other fruits such as cucurbits, citrus, litchi and quality losses in dragon fruit can also be high. Certain species of fruit fly are quarantine pests in various countries and the export of susceptible fruits is therefore only possible after agreed quarantine treatments, which are not currently available. Information on the fruit fly species that occur in Vietnam, the fruits infested by these species and the related losses is very limited. No control measures specifically designed for fruit fly are applied.

Fruit fly management is an essential component of IPM in fruit. Therefore, integrated fruit fly management strategies, based on physical (bagging) and cultural (crop hygiene, early harvesting) measures, the preservation and use of natural enemies and the selective use of pesticides such as protein/ insecticide bait sprays, need to be field validated. Where found effective, a farmer training programme should be launched to promote the wide scale use of these strategies. Such a training programme should also cover IPM for other fruit pests and diseases and crop management, as required.

The data generated by the trapping of fruit flies, host surveys, damage surveys and bait spraying would provide essential technical information to comparable projects on IPM in fruits and vegetables in the region, in term of improving the quantity and quality of horticultural produce and fruits for local consumption. The data would also make it possible to develop quarantine treatments and protocols to gain access to export markets. In addition, by carrying out these activities, a national capacity in fruit fly management would be developed.

The Government of Vietnam sought assistance for the development of sustainable fruit fly management for the Australian Centre for International Agricultural Research and the Australian Technical Assistance Agency. It was in this context that the Government of Vietnam requests FAO assistance.

2. Outline of official arrangement

This assistance was approved on 26 November 1998 under the Technical Cooperation Programme project TCP/VIE/8823 "Fruit Fly Management" with a schedule duration of 14 moths and a budget of $US 250 000, subsequently increased to $US 278 000. The project was implemented by the Ministry of Agriculture and Rural Development. The government counterpart institution responsible for project execution was the National Institute of Plant Protection (NIPP), Hanoi, in collaboration with the Southern Fruit Research Institute (SOFRI), Long Dinh (Mekong Delta).

The project provide the services of one International Consultant to provide technical inputs and training in fruit fly trapping, fruit damage surveys and fruit fly identification (two months in five missions); two Technical Co-operation among Developing Countries (TCDC) Consultant for training in the use of bait sprays and in

fruit fly rearing (one month); and one Retired Expert to assist in the assessment of the results of the project and to advise on follow-up activities (three weeks). In addition, two backstopping visits were made by FAO Plant Protection Officer from FAO Subregional Office for the Pacific. Operating funds were provided to cover the costs of the planned activities. The budget also covered s study tour by two national staff members (from NIPP and SOFRI) to the Regional Fruit Fly Project in Fiji and to Griffith University, Brisbane, Australia. The materials and supplies provided by the project consisted in attractants, traps, laboratory rearing materials and chemicals. The equipment provided included a microscope, computer, drying oven, air conditioner, fridge food blender, camera and small laboratory materials for the implementing institutions (NIPP) SOFRI) and a vehicle (NIPP). In addition, books, manuals, traps, lures, protein bait and other small items were supplied by Griffith University through a Letter of Agreement, which also covered the identification of the fruit flies and related activities.

The Government nominated a Project Leader, a Team Leader at NIPP and at SOFRI and other project personnel. Office and laboratory facilities were made available at both institute.

The project became operational in March 1999, when the Project Planning Workshop was held, and was extended in November 1999 to October 2000, without any further budget increase, to allow sufficient time for additional field trials and training.

3. Objective of the project

The objective was to strengthen the national capacity to manage pest fruit flies in order to maximize the implementation of IPM programmes for fruit and vegetable production.

The project was expected to:

- Identify pest fruit fly species in Vietnam
- Compile preliminary host ranges for commercial/edible fruits and vegetables fruits.
- Estimate levels of damage caused by fruit flies to fruits such as mango, guava, cucurbits and dragon fruit in southern Vietnam and peach and citrus in northern Vietnam
- Compile an inventory of fruit fly control methods currently used by farmers at the commercial and subsistence levels and assess their effectiveness
- Establish laboratory colonies of the key pest species to be used to determine the effectiveness of bait spray in the laboratory and in the field and fruit susceptible to fruit flies.

- Initiate preliminary bait spray testing and training in its use
- Train national staff in fruit fly surveys and fruit fly identification, laboratory rearing, loss assessment and field control techniques, and
- Formulate a follow-up project for submission to international donors or for national funding.

4. Project implementation

The Project Planning Workshop and training for 15 participants was held in Hanoi on 18-19 March 1999 during the first mission of the International Consultant (17-26 March 1999) and the FAO Plant Protection Officer (17-21 March 1999). The participants were familiarized with techniques for fruit fly surveys, the identification of species and pest management and the preliminary work plan was finalized. The first training workshop was held at NIPP on 19-23 July for 15 participants during the second visit by the International Consultant (12-24 July 1999), while a second workshop was held at SOFRI on 1-5 September 1999 for 22 participants during the third mission of the International Consultant (25 October- 1 November 1999). These workshop covered, among other topics, fruit fly identification, fruit fly surveys, fruit damage assessment, bait sprays, discussion of the results obtained and the planning of activities. Towards the end of the project (27-28 November) the overall results were presented at the Project Review Meeting to government officials, plant protection and horticulture experts and researchers, extension officers, donor representatives and others Priorities for follow-up activities were identified.

In addition to the support given to the workshops, the International Consultant conducted backstopping missions on 17-22 April 2000 and 24-29 September 2000 to provide guidance to the project activities and the Project Review Meeting. The FAO Plant Protection Officer conducted a further backstopping mission on 18-22 April 2000, while the TCDC Consultant gave training in bait spraying on 2 May- 11 June 1999. The Retired Expert conducted his mission on 10-30 November 2000 and participated in the Project Review Meeting. The study tour by staff members from NIPP and SOFRI took place on 30 April – 15 May 1999. The topics covered included the biology of fruit flies, taxonomy, eradication, integrated control, surveillance, protein bait sprays and fruit damage assessment. Because of already heavy work plan of the project staff, it was decided to postpone setting up fruit fly colonies to a follow- up phase and the consultancy on fruit fly rearing was not implemented.

Detailed training manuals were prepared for the participants of the training workshops on topics such as fruit fly identification the biology of Asian and Pacific fruit flies, fruit fly trapping, host assessment, the processing of data and field control.

These were made available to the participant of the workshops. Study collection of identified pinned fruit flies were prepared to facilitate fruit fly identification and made available to NIPP and SOFRI.

Fruit fly traps were set up with the attractant cue lure (CL) or methyl eugenol (ME), which are specific for different fruit fly species. The traps were emptied at intervals of one or two weeks, depending on the location. The flies were identified in Australia by the International Consultant and the results were returned to the project. In northern Vietnam 19 trapping sites, each with a CL and a ME trap, were established. The CL traps collected over 6000 flies belonging to 16 species, while the ME traps collected over 10 000 flies belonging to 4 species. In southern Vietnam, 20 trapping sites were operational. The CL traps attracted over 8000 flies belonging to 11 species, while the ME traps collected over 55 000 flies belonging to 6 species.

Cultivated fruits and vegetables and wild fruits were collected, brought to the laboratory and kept until any fruit fly present had emerged. In northern and coast central Vietnam, 576 samples were collected. Fruit flies emerged from 15 species of cultivated fruits, from 10 species of vegetable fruits and from 5 species of wild fruits. In southern Vietnam, 1 083 samples of cultivated fruits, vegetable and wild fruits were collected. Fruit flies were bred from 12 species of cultivated fruit, 9 species of vegetable fruits and 4 species of wild fruits.

Some assessments were made of fruit fly infestation in selected fruits by means of random sampling. The bait spray trials also provided useful information on the percentage of fruit infestation in the course of the year. These studies provided estimates of crops damage to selected crops over a production season.

In northern Vietnam, two bait spray trials were conducted on peach, one on guava and one on citrus. In southern Vietnam, two bait spray trials were conducted on guava, one on bitter gourd and one on water apple.

Close contact was maintained with potential donors to obtain support to continue or initial selected activities after the termination of the project.

RESULTS AND CONCLUSION

1. Fruit fly fauna, distribution and hosts

A first inventory was made of the fruit fly species that occur in Vietnam. In northern Vietnam, a total of 20 species was trapped and, in southern Vietnam, 17 species. Ten species occur in both the north and the south. Significantly high numbers

of *B. correcta* and *B. dorsalis* flies were trapped in the south. A more in depth analysis of the trapping data would probably provide essential information on the occurrence of the most common species in the course of the year.

The species *B. correcta, B. cucurbitae, B. dorsalis, B. latifrons, B. pyrifoliae* and *B. tau* were bred from commercial fruits and vegetable fruits collected in the north and south. There is considerable published information available on the biology of *B. caramholae, B. cucurbitae* and *B. dorsalis*. The information on the biology of these species needs to be verified under Vietnamese conditions. The biology of the other species is not well known and needs to be studied.

2. Fruit infestation

Farmers in northern Vietnam consider fruit fly infestation important in peach, pear, guava, litchi, water apple, suchu, luffa and bitter luffa. Quantitative data, based on random sampling, could only be collected in conjunction with the bait spray trials. In the 1999 trial almost 8% of peach was infested in early June. This figure rose quickly to almost 50% by the end of June to reach 60% by mid July. In the 2000 trial, infestation was much less and this was ascribed to the prevailing low pest population. At the beginning og July infestation was 2% and gradually increased to 21% by mid- August. The likely explanation of the low pest population is that the exceptionally severe winter reduced the over- wintering population of the fruit flies. In another bait spray trial the infestation of guava was around 5% in August and around 12% in early September.

Farmers in southern Vietnam consider fruit fly infestation important in guava, jujube, water apple, certain longan varieties and, to a much lesser extend, mango and citrus. A crop damage assessment study showed that, from October to December, a low percentage of guava was infested. Infestation rose sharply in January to 33% and increased to 94% in March. Infestation levels in July- August were 11-16%. Infestation in water apple was 76% in May, 51% in June and 46% in July. Similarly high levels of infestation for this period were found in a bait spray trial. Almost 8% of bitter gourd was found to be infested in July. In a bait spray trial infestation levels of 0% were found around the end of July. These increased, however, to 18% by mid- August. No fruit flies emerged from samples of dragon fruit, eggplant, mango and tomato.

These results show the large variation between fruit species in fruit damage in the course of the year and the possible variation in pest pressure between years in mountain areas, depending on the severity of the winter. It seems that, in the south, fruit fly population are low during the rainy season. An analysis of the numbers of flies trapped in the course of the year may confirm this relationship. For the effective use of bait sprays it is essential to collect more information on fruit infestation and its progress in

the course of the ripening season. In addition, a better understanding is required of the susceptibility of the different ripening stages of the fruits for fruit flies.

3. Bait sprays

A trial was conducted in Sapa district (Lao Cai province, northern Vietnam) on peach trees in May/July 1999. Each tree of a block of 100 trees was sprayed at weekly intervals with 50 ml of mauri protein mixed with 10 ml of chlorpyrifos 20%EC. The trial lasted 7 weeks. The percentage of damages fruit was assessed at weekly intervals and compared with fruit infestation in a nearby block of 100 untreated trees. The results showed that the bait spray suppressed fruit damage almost completely, in particular towards the end of the experiment was repeated at the same locality in July/August 2000. Fruit fly populations, however, were apparently very low because, during the trial, fruit damage in untreated trees slowly increased to 21% after 6 weeks. In treated trees the final damage was 14%.

A similar experiment was conducted on guava in Thanh Liem district (Ha Nam province) in July/August 2000. After 5 weeks the percentage of infested fruit in the untreated crop was 12%, while, in the treated crop, it was only 7%. An experiment on citrus in Cao Phong/Hoa Binh district (Hoa Binh province) was discontinued after three weeks because the infestation was insignificant.

A protein bait spray trial was conducted in a guava plantation in Caibe district (Tien Giang province, southern Vietnam) from October 1999 to early March 2000. The bait spray and rate of application was the same as that described for northern Vietnam. During heavy rain periods from the beginning of the trial to late December, fruit fly infestation was very low. However, from early January 2000, the infestation level steadily increased to 100% in the two untreated control plots and to 86% in the treated plot. It appeared that chlorpyrifos was not an effective insecticide to use in bait sprays, probably because it breaks down rapidly on the leaf surface. Another mixture, consisting of mauri protein (375ml) and fipronil (37.5g gel powder) was tested on guava at Long Dinh (Tien Giang province). Fruit infestation in the untreated plot ranged between 10 and 20% in July/August. The initial infestation in the fipronil treated plot was 41% but sharply decreased to 4% in August.

An experiment with malathion bait spray (50 ml mauri protein + 5 ml malathion 50% EC) on bitter gourd showed no difference between treatment and control. In a trial on water apple in Cai Be district, in which the effectiveness of bait sprays of malathion, chlorpyrifos and fipronil were compared, fipronil proved to be the most effective.

The results of the bait spray trials were not conclusive and showed that the composition of the bait spray, the experimental layout or the application techniques needed to be improved. Laboratory colonies of the most important fruit flies have to be established to test the attractiveness of the bait sprays. It may also be necessary to conduct the trials on larger plots considering the high fruit fly pressure from the surrounding areas. In addition, a better understanding of the time of fruit fly emergence and of fruit fly development in different climatic conditions, as well as much more field testing, is required for the cost effective use of bait sprays. Of particular importance is the correct timing of the sprays. When these are applied to late, after the emergence of the flies, the flies are no longer attracted to the baits.

The results of the first trial in Sapa district are, however, very positive. An almost complete protection was achieved in peach and the sampling data showed that fruit infestation progress very rapidly if the flies are not controlled. The trial in the south showed the greater effectiveness of fipronil compared to organophosphates, malathion and chlorpyrifos.

4. Farmer practices

Farmers in general are aware of the problems fruit flies may cause but have little or no understudying of the life cycle of fruit flies. Early harvesting is used to avoid fruit fly infestation. Farmers in the south often do not harvest guava in January- March because of the very high infestation by fruit flies. Insecticide sprays may be applied when fruit fly larvae are observed in the fruits. Such treatments are not effective and create more problems than they solve. One farmer demonstrated a common weed that, after crushing, almost immediately attracted *B. correcta* and remained attractive for at least half an hour. it was said that farmers sometimes mix this weed with the insecticide furadan to kill fruit flies. Although interesting, the method is ineffective, as it attracts only male flies. There is, a need to better understand farmers' views and practices with respect to fruit fly control.

5. Follow up activities

The International Consultant assisted NIPP to secure funds from Australian donors for the continuation of activities for four years, from July 2001.

The bilateral New Zealand Official Development Assistance- Appropriate Development for Africa Foundation project "Development of Protocols to Overcome Quarantine Barriers for Vietnamese Export" which recently became operational, will make full use of the results of the current project.

RECOMMENDATION

It is essential for the cost effective management of fruit flies that a locally- made inexpensive bait spray be made available. It is recommended that such a bait spray be developed as soon as possible, making use of yeast waste from a local brewery.

Laboratory tests with fruit flies are required to assess the attractiveness and effectiveness of bait sprays. It is recommended that laboratory colonies of the important fruit flies be established and maintained at NIPP and SOFRI..

Useful experience was gained in the conducted of bait spray trials but the number of trials was small. It is therefore recommended that the developed bait sprays be field tested under different climatic conditions and on different fruits before their use is advised on a large scale. In the field testing trials, due attention should be given to the location and size of the trial sites, replication, sampling procedures and application techniques.

The project identified some of the major cultivated fruits that are liable to fruit fly infestation. For the development of effective fruit fly management practices, such as early harvesting of the use of bait sprays, the susceptibility to the relevant fruit flies of the subsequent ripening stages of the fruits should be better known. It is therefore recommended that such data be collecting such trials, due attention should be given to the correct identification of the fruits and fruit varieties.

Sometimes there appears to be confusion about the correct Latin names of the fruits collected and their corresponding English and local names. It is recommended that photographs be taken of the fruit collected in case of doubt of the identity or variety and that expert advice be sought for their correct identification. The establishment of a pictorial data base on the fruits and varieties cultivated in Vietnam would be of great use to the fruit fly programme.

There is much published information on the biology of fruit fly species as *B. cucurbitae* and *B. dorsalis* from studies conducted in other countries. However, information on the biology of other species which are of importance for Vietnam is very limited or not available. It is recommended that the available information on well-studied fruit fly species be verified under Vietnamese conditions and that studies be initialed on less well- studied species such as *B. correcta* and *B. pyrifoliae*. Such studies would be suitable topics for university students.

The information on the occurrence of fruit flies and fruit infestation in central Vietnam is very limited. It is recommended that fruit fly and host surveys be conducted in this area.

The project trained a nucleus of fruit fly researchers and initiated the training of provincial plant protection and extension officers. These training activities should be intensified and focused increasingly on farmers. Intensive training programmes should be developed and launched for plant protection officers, extensionists and farmers. Full use should be made of the experiences if the FAO Programme for Community IPM with experimental learning and non – formal education. The training should gradually include other components of integrated production and protection. The training of farmers, however, should only start when an effective, locally produced bait spray is available. The training of extension officers in fruit fly recognition and biology; IPM in fruit production and farmer participation in IPM development and implementation should be initiated immediately

The project produced a wealth of information on the occurrence if fruit flies, fruit infestation and possibilities for fruit fly management. Much of this information is new for Vietnam and for South Asia in general. It is recommended that it be analyzed in more detail and published in a national or international journal.

Much progress was made in securing funds from interested donors for follow-up activities. The discussions regarding these should continue in order to reach decisions as soon as possible.

It may take some time before donor funds can be mobilized. It is recommended that adequate national funds be made available to continue selected project activities, such as fruit fly survey in central Vietnam, season- long fruit fly trapping in selected fruit growing areas, the setting up of laboratory colonies of key fruit fly species and the assessment of the susceptibility of the different fruit ripening stages to fruit flies.

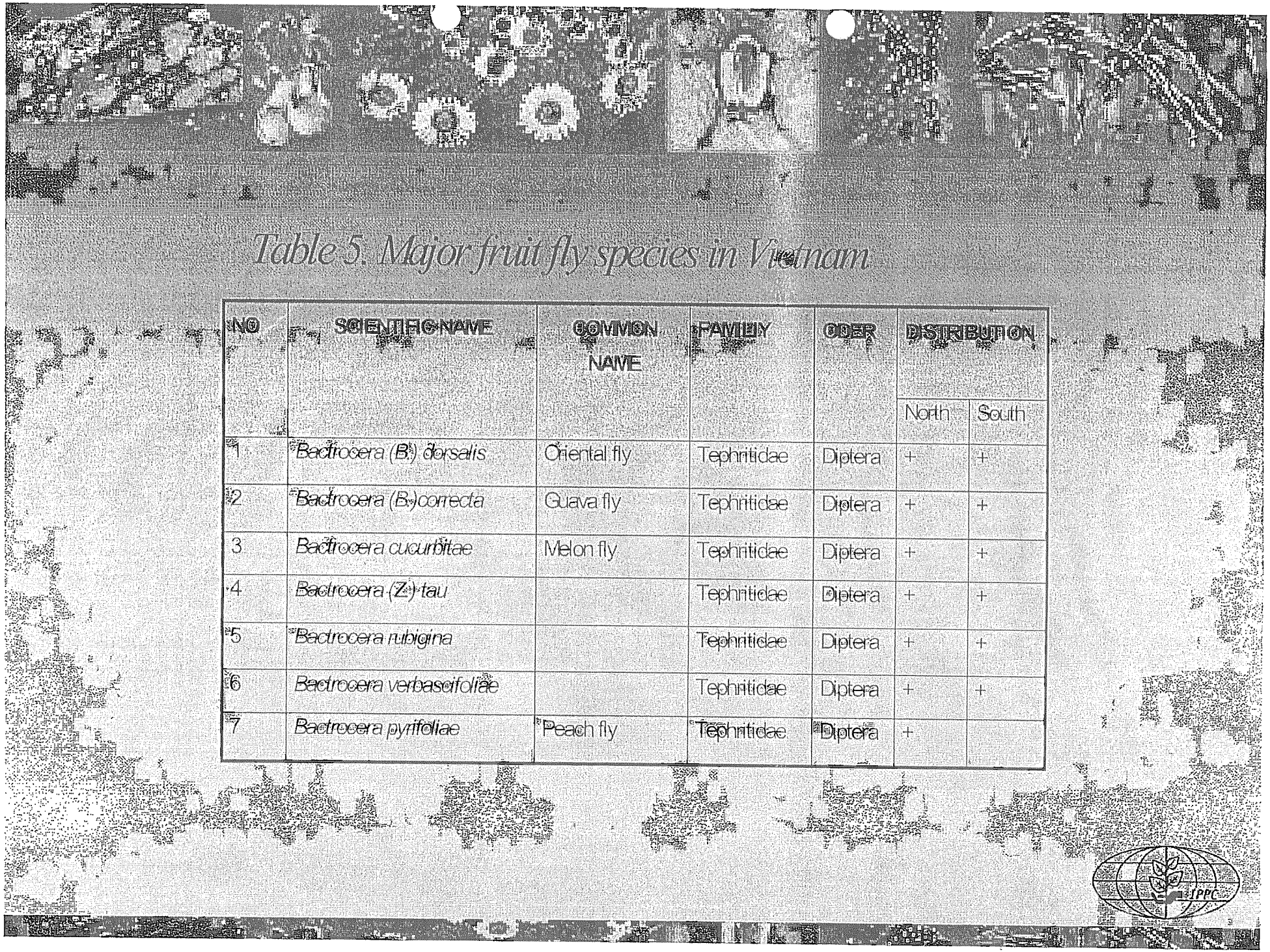


Table 5. Major fruit fly species in Vietnam

NO	SCIENTIFIC NAME	COMMON NAME	FAMILY	ORDER	DISTRIBUTION	
					North	South
1	*Bactrocera (B.) dorsalis*	Oriental fly	Tephritidae	Diptera	+	+
2	*Bactrocera (B.) correcta*	Guava fly	Tephritidae	Diptera	+	+
3	*Bactrocera cucurbitae*	Melon fly	Tephritidae	Diptera	+	+
4	*Bactrocera (Z.) tau*		Tephritidae	Diptera	+	+
5	*Bactrocera rubigina*		Tephritidae	Diptera	+	+
6	*Bactrocera verbaseifoliae*		Tephritidae	Diptera	+	+
7	*Bactrocera pyrifoliae*	Peach fly	Tephritidae	Diptera	+	

1. *List of host plants (common (English) and scientific names in the order of importance)*

Table 6 : LIST OF FRUIT FLY HOSTS IN VIETNAM

No	Common name	Scientific name	Location (*)	Fruit fly species (**)
1	Guava	*Psidium guayava*	S,N	BCO,BDO, BPY
2	Rose apple	*Zyzygium jambos*	N	BCO, BDO
3	Curstard apple	*Annona squamosa*	S,N	BDO
4	Bitter gourd	*Momordica charantia*	S	BCU, BTA
5	Cucumber	*Cucumis sativus*	S, N	BCU
6	Jujube	*Ziziphus mauritiana*	S	BCO, BDO
7	Lychee	*Litchi chinensis*	N	BDO
8	Malay apple	*Eugenia malaccenis*	S	BCO, BDO,BCA
9	Orange	*Citrus sinensis*	S, N	BDO , BCU
10	Papaya	*Carica papaya*	S, N	BDO, BTA
11	Peach	*Prunus persica*	N	BDO , BPY
12	Pear	*Pyrus communis*	N	BDO
13	Persimmon	*Diospyros kaki*	N	BDO
14	Plum	*Prunus domestica*	N	BDO

No	Common name	Scientific name	Location (*)	Fruit fly species (**)
15	Melon	*Cucumis spp*	N	BCU
16	Pumpkin	*Cucurbita pepo*	S, N	BCU, BDO, BTA
17	Sapodilla	*Achras sapota*	S	BCO, BDO
18	Wampei	*Clausena lansium*	N	BDO
19	Water apple	*Eugenia javanica*	S	BCO, BDO
20	Common jujube	*Ziziphus jujuba*	N	BDO
21	Bitter luffa	*Luffa acutangula*	N	BCU
22	Chayot	*Sechium edule*	N	BTA
23	Chili	*Capsicum annuum*	N	BCU
24	Carambola	*Averrhoa carambola*	S	BCO ,BDO,BCA
25	Mango	*Mangifera indica*	S	BCO, BDO
26	Pomelo	*Cirus grandis*	S, N	BDO
27	Rag gourd	*Luffa aegyptiaca*	N	BCU, BCO, BDO, BTA, BPY
28	White gourd (squash)	*Benincasa hispidas*	S	BCU, BDO, BTA
29	Dragon fruit	*Hylocereus undulatus*	S	BDO

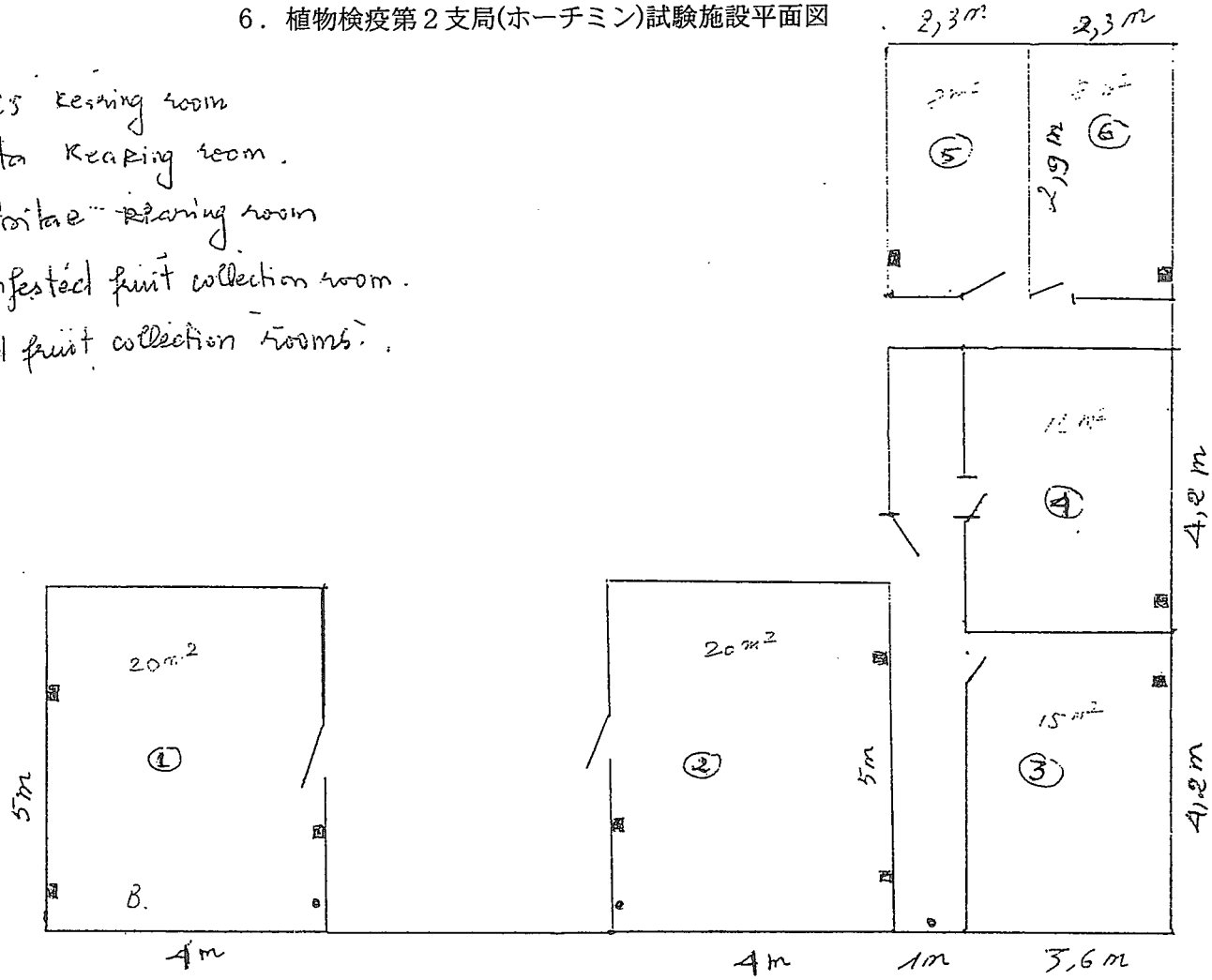
(*) : S: South Vietnam N: North Vietnam

(**) : Abbreviated name of fruit fly species

6．植物検疫第２支局(ホーチミン)試験施設平面図

Note:

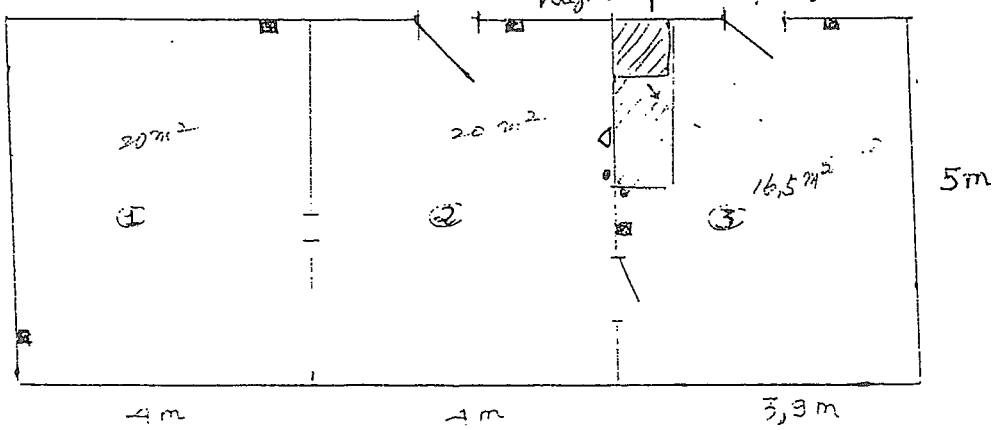
① B. dorsalis Rearing room
② B. correcta Rearing room.
③ B. cucurbitae Rearing room
④ Infested fruit collection room.
⑤⑥ Infested fruit collection rooms.



FIRST FLOOR.

① : Fruit holding room.
② : Experiment preparation room.
③ : Heat Treatment room.

▣ : power electric (220V)
• water
▲ hot water
door : 1,2m x 2,2m.
hight of room : 3,55m



GROUND FLOOR.