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公 務 出 國 報 告 提 要

頁數: 33　合附件: 是

報告名稱:

參加亞太經濟合作(APEC)管制植物病蟲害越境移動之診斷研討會報告

主辦機關:

行政院農業委員會動植物防疫檢疫局

聯絡人／電話:

張慧永／23434414

出國人員:

張弘毅　行政院農業委員會動植物防疫檢疫局　植物防疫組　副組長

出國類別: 其他

出國地區: 澳大利亞

出國期間: 民國 90 年 07 月 01 日 -民國 90 年 07 月 07 日

報告日期: 民國 90 年 08 月 30 日

分類號/目: F7／農品檢疫及家畜保健　F7／農品檢疫及家畜保健

關鍵詞: APEC,植物病蟲害,管制,診斷

內容摘要: 奉派赴澳大利亞參加APEC農業技術合作小組的動植物檢疫及病蟲害管理分組第五次會議—管制植物病蟲害越境傳播之診斷研討會，該會議的主要決議包括：1.加強地區間植物病蟲害診斷設備及需求之評估及充實。2.加強對區域間重大病蟲害文獻之蒐集及資料電子化、網路化。3.建置區域間的網路討論群(Listsever)，以促進診斷及疫情資訊交流。4.建立各國主要病蟲害清單，並加強區域內之合作研究。5.建立病蟲害診斷鑑定標準程序及作業方法，並將其訂定爲國際標準。6.建立各國檢疫上所截獲病蟲害及新入侵病蟲害資料，並據以建立預警網路。本次與會主要心得及建議如下：1.加強與各國間之植物防疫技術合作，以利掌握國外疫情，並在國外建立病蟲害的防護牆。2.建議及早規劃我國預定於2002年10月舉辦之下一次APEC研討會相關事宜，並寬列經費辦理。3.建議加強與各國間之疫情資訊合作，積極參予建置亞太地區或東亞地區植物疫情網之規劃。

本文電子檔已上傳至出國報告資訊網

C09004051

行政院及所屬各機關出國報告提要

出國報告名稱：

參加亞太經濟合作(APEC)管制植物病蟲害越境移動之診斷研討會報告

頁數 187　　　含附件：是

主辦機關：

行政院農業委員會動植物防疫檢疫局

聯絡人/電話

柯榮輝科長/2343-1458

出國人員：

張弘毅 行政院農業委員會動植物防疫檢疫局植物防疫組　副組長

出國類別：出席國際會議

出國期間：90 年 7 月 1 日至 7 月 7 日

出國地區：澳大利亞

報告日期：90 年 7 月

分類號/目：

關鍵詞：APEC、植物病蟲害、管制、診斷

內容摘要：奉派赴澳大利亞參加 APEC 農業技術合作小組的動植物檢疫及病蟲害管理分組第五次會議—管制植物病蟲害越境傳播之診斷研討會，該會議的主要決議包括：1.加強地區間植物病蟲害診斷設備及需求之評估及充實。2.加強對區域間重大病蟲害文獻之蒐集及資料電子化、網路化。3.建置區域間的網路討論群(Listsever)，以促進診斷及疫情資訊交流。4.建立各國主要病蟲害清單，並加強區域內之合作研究。5.建立病蟲害診斷鑑定標準程序及作業方法，並將其訂定為國際標準。6.建立各國檢疫上所截獲病蟲害及新入侵病蟲害資料，並據以建立預警網路。本次與會主要心得及建議如下：1.加強與各國間之植物防疫技術合作，以利掌握國外疫情，並在國外建立病蟲害的防護牆。2.建議及早規劃我國預定於 2002 年 10 月舉辦之下一次 APEC 研討會相關事宜，並寬列經費辦理。3.建議加強與各國間之疫情資訊合作，積極參予建置亞太地區或東亞地區植物疫情網之規劃。

本文電子檔已上傳至出國報告資訊網(http://report.gsn.gov.tw)

參加亞太經濟合作(APEC)管制植物病蟲害越境移動之診斷研討會報告

摘要

奉派赴澳大利亞參加 APEC 農業技術合作小組的動植物檢疫及病蟲害管理分組第五次會議—管制植物病蟲害越境傳播之診斷研討會，該會議的主要決議包括： 1.加強地區間植物病蟲害診斷設備及需求之評估及充實。 2.加強對區域間重大病蟲害文獻之蒐集及資料電子化、網路化。 3.建置區域間的網路討論群(Listsever)，以促進診斷及疫情資訊交流。 4.建立各國主要病蟲害清單，並加強區域內之合作研究。 5.建立病蟲害診斷鑑定標準程序及作業方法，並將其訂定為國際標準。 6.建立各國檢疫上所截獲病蟲害及新入侵病蟲害資料，並據以建立預警網路。本次與會主要心得及建議如下： 1.加強與各國間之植物防疫技術合作，以利掌握國外疫情，並在國外建立病蟲害的防護牆。 2.建議及早規劃我國預定於 2002 年 10 月舉辦之下一次(第六次)研討會相關事宜，並寬列經費辦理。 3.建議加強與各國間之疫情資訊合作，積極參予建置亞太地區或東亞地區植物疫情網之規劃。

目　次

壹、緣起與目的

亞太經濟合作(Asia-Pacific Economic Cooperation，簡稱 APEC)係亞太地區各經濟體間於一九八九年成立之區域間組織，目前共有二十一個會員國，其成立之目的是在藉由推動貿易暨投資自由化手段達成加強亞太地區經濟合作之目標。為增進 APEC 會員國之農業技術合作進而提昇整體經濟效益，APEC 於一九九六年成立「農業技術合作專家小組」(Agricultural Technical Cooperation Experts Group, ATCEG)，其後於二〇〇〇年十一月在汶萊舉行的部長級會議中將其更名為「農業技術合作工作小組」(Agricultural Technical Cooperation Working Group，簡稱 ATCWG)。目前在該工作小組架構下依據技術的類別設有七個分組，其中之一即為動植物檢疫及病蟲害管理分組(Sub-group on Plant and Animal Quarantine and Pest Management)。

ATCWG 下的動植物檢疫及病蟲害管理分組(以下簡稱動植物檢疫分組)已舉辦過四次的研討會，其中三次為有關植物的部分，分別在夏威夷檀香山、澳洲肯因茲(Cairns)及夏威夷柯那(Kona)舉行，前兩次研討會的主題為病蟲害風險分析，第三次為檢疫處理用溴化甲烷替代物之研討會。第四次為動物健康風險分析研討會在澳大利亞布利斯班召開。該四次會議我國均曾派員參加。本次為該分組的第五次會議，會議名稱為亞太經濟合作管制植物病蟲害越境傳播之診斷研討會(APEC Workshop to Contain Transborder Movement of Plant Pest: Diagnosis)，會議係於九十年七月三日至七月六日於澳大利亞布利斯班召開。本次會議係由澳洲農林水產部(Department of Agriculture, Fisheries & Forest – Australia，簡稱 AFFA)、熱帶植物保護合作研究中心(the Cooperative Research Centre for Tropical Plant Protection，簡稱 CRCTPP)主辦，並由澳洲國際發展局(Australian Agency for International Development，簡稱 AusAID)及澳洲國際農業研究中心(the Australian Centre for International Agricultural Research，簡稱 ACIAR)聯合支助經費。參加本次會議的代表共四十四人，來自十六個 APEC 經濟體，名單詳如附件一。為強化我國參與 ATCWG 相關會議之主導功能，以及爭取下一次即第五次工作小組會議在我國舉辦之機會，

在外交部經費支助下由行政院農業委員會動植物防疫檢疫局派員與會並做報告。

貳、行　程

日　　期	地　　點	活 動 內 容
七月一日	台北→澳大利亞布利斯班	啟程
七月二日	澳大利亞布利斯班	會前會
七月三—六日	澳大利亞布利斯班	正式會議
七月七日	澳大利亞布利斯班→台北	回程返國

參、研討會內容

本次研討會的中心議題為如何落實各經濟體間的病蟲害診斷合作，以減少因欠缺病蟲害鑑定設備或疫情資訊不足而影響到國際間農產品的貿易，以及如何更有效杜絕病蟲害的越境傳播。研討會的主要目標在於：㈠釐清亞太地區重大病蟲害之種類，㈡評估各經濟體對該些重大病蟲害偵測及管理的能力及有關的診斷資源是否充足，㈢剖析各經濟體建立植物病蟲害資料之能力，以及如何促進彼此間之合作，㈣發展亞太地區間重要病蟲害之診斷及疫情交流網路。會議共舉行三天半，期間並安排前往會場附近的兩個研究單位參觀，會議內容詳如附件二。

本次會議的主題共可分為八個部分，分別為：㈠ APEC 地區植物健康問題之回顧，㈡各國代表發表其國內之現況報告，㈢食品衛生檢驗及動植物防疫檢疫措施協定(SPS)相關事務之綜述，㈣地區間發展植物健康的網路活動現況，㈤各國代表所報告資料之分析討論，㈥澳洲的植物病蟲害調查及監測體系介紹，㈦植物病蟲害診斷技術概述，㈧結論—如何發展亞太地區間整體的診斷技術水準等。其中第㈠㈢㈣㈥㈦議題是由主辦單位邀請澳洲當地專家及少數由國外邀

請的專家做專題報告。其餘三項議題則由各參加代表以分組討論方式作腦力激盪討論，以提出具體的建議，而後再將各分組所提出之建議加以整合，並做出共識性結論。

有關上述各主題的主要研討重點內容摘述如次：

㈠ APEC 地區植物健康問題之回顧

此議題主要係由澳洲及美國專家發表專題報告。鑑於植物病蟲害的危害問題及其嚴重性為各經濟體所共同關切之項目，因此在該主題中，主要是讓各經濟體了解病蟲害診斷在國際貿易上之重要性。例如，植物檢疫證明書上常用的"不知其發生(not known to occur)"字眼，其實是不夠嚴謹的，因為要證明一種病蟲害在本地確實未發生，應該是在經過充分的病蟲害發生調查、監測及診斷鑑定後，才能"確知其未發生(known not to occur)"。該兩句的用語其實存在很大的差異。因此，呼籲各經濟體為有效避免植物病蟲害在國境間蔓延傳播，極有必要發展區域間的合作機制，其重點則應包括：建立病蟲害診斷、監測網路，設置完善之病蟲害診斷設施及疫情系統，以及針對重大病蟲害進行研究，以達到資源互享及技術、專家合作的目標。同時，有鑒於正確的病蟲害鑑定是採取有效檢疫或防疫措施之基礎，因此推動加強區域間的診斷鑑定合作、疫情交流及病蟲害風險分析亦為當前很重要的課題。

㈡各國代表發表其國內之現況報告

依據原先主辦單位規劃之問卷，各經濟體代表主要就各國之㈠植物防疫及檢疫架構，㈡診斷鑑定體系及設備，㈢主要病蟲害種類、疫情資訊交流及㈣病蟲害診斷上之需求及限制因子等項重點作專題報告。共有十二個經濟體作報告，由我國首先開始，其次為香港、印尼、日本、韓國、馬來西亞、巴布亞新幾內亞(臨時缺席)、中國大陸、菲律賓、新加坡、泰國及越南等經濟體。我國報告內容主要在說明我國的病蟲害診斷鑑定系統十分完備且行之有年，而且診斷鑑定亦需有病蟲害偵測體系相配合才能達成目標，其中疫情管制及通報系統亦為其中重要的一環（詳如附件三）。本議題中，由於各經濟體間科技程度相差懸殊，因此開發中的經濟體大多反映出其專家、技術、設備、經費及訓練不足等

的問題。但就整體而言，各代表均對於整合地區間的病蟲害診斷資源均認為至有必要，且抱極大的希望。

㈢食品衛生檢驗及動植物檢疫措施協定(SPS)相關事務之綜述

主要係澳洲專家針對 SPS 相關之事務作專題報告，申明各國所採之檢疫措施必須依據國際規範辦理。同時由於病蟲害的正確診斷係維持國際農產品貿易安全，進而確保各國農業生產及品質之重要措施。為達此目的，澳洲政府在相關單位的支助下，已陸續和部分國家進行合作研究，例如在 ACIAR 的經費支助下，與亞洲地區的馬來西亞、泰國及不丹等國家，以及南太平洋的大多數國家正在進行一項大區域性的果實蠅的調查及診斷鑑定計畫。此外對於銀葉粉蝨、蜂蟎、甘蔗病蟲害等的監測調查計畫也在 ACIAR 的支助下，在部分的亞太地區經濟體間進行合作研究。

㈣地區間推動植物健康的網路活動現況

1.澳洲

為整合澳洲的診斷鑑定網路，目前有兩項計畫在推動中，一項是由澳洲植物健康股份有限公司(Plant Health Australia Limited)所提供經費支助的澳洲病蟲害診斷鑑定服務資源調查，其對象包括各公部門及私部門，該計畫完成後將可作為澳洲將來整合鑑定網路之重要依據。另一項是由 CRCTPP 所執行的以澳洲北部病蟲害診斷網(Northern Australian Diagnostic Network,簡稱 NADN)為主的「保護澳洲農業抵抗外來及本地病蟲害」的研究計畫。而為提昇診斷鑑定水準，昆士蘭主要生產部(Queensland Department of Primary Industries)在 Idooroopilly 也設立一個分子多樣性及診斷研究試驗室，並且集合分子生物專家、病蟲害專家及相關技術人員進行團隊合作研究。同時，依據病蟲害的經濟重要性、檢疫重要性和技術可行性，澳洲政府目前已選定重點病害調查的對象包括：甘蔗黑穗病(Sugarcane smut)及蕃茄斑萎病毒(tospoviruses of tomato and capsicum)、疫病屬(*Phytophthora* sp.)、棉花立枯病(*Fusarium oxysporum* f.sp. *vasinfectum*)、香蕉葉斑病(*Mycosphaerella fijiensis*)、細菌性條斑病(*Acidovorax avenae*)、香蕉細菌性萎凋病(Banana blood disease)、青枯病菌(*Ralsnia* *solanacearum*)、穀物及甘蔗露菌病(Downy mildews)及香蕉萎縮病(banana bunchy top virus)等。另外，在重點害蟲的鑑定方面，澳洲已完成 80 種檢疫重要果實蠅類的分子生物技術快速鑑定技術開發，且亦研發出多套的害蟲及害蟎的電腦輔助診斷鑑定系統。而利用新近的數位影像技術，有關病蟲害的鑑定及描述工作已變得更加容易及迅速，尤其藉著新近的網際網路技術之廣泛使用，未來各經濟體間進行資訊的交換及分享將更為方便，且對提昇整體診斷鑑定技術及知識交流會有很大的幫助。

2.南太平洋地區

南太平洋地區的病蟲害診斷網路目前主要是由太平洋共同體秘書處(Secretariat of the Pacific Community，簡稱 SPC)下的植物保護局來負責推動。SPC 除推動該區域性的病蟲害診斷網路外，也進行病蟲害監測、訓練及鑑定工作。在電腦資訊網路方面，南太平洋地區所建置的太平洋網(PACINET)亦提供病蟲害鑑定、技術移轉、資訊及進行專家訓練課程。而在 SPC 植物保護局所架設的網站 (http://www.spc.int/pps) 則提供病蟲害簡訊、防治技術指導、病蟲害預警等資料。此外，太平洋地區果實蠅網站(http://www.pacifly.org)則提供本地區果實蠅監測及防治的相關資料。但就整體而言，本地區由於專家、經費及資源普遍較缺乏，因此仍有賴其他地區之奧援。

3.亞太地區

成立於一九九六年的亞太網(ASEANET)是東南亞地區提供有關植物病蟲害診斷資訊的一個主要網站，目前參與該網路的國家計有汶萊、高棉、印尼、寮國、馬來西亞、緬甸、菲律賓、新加坡、泰國及越南等十個。ASEANET 和上述的 PACINET 都是屬於全球生物網(BioNET)的一個部分，BioNET 的整體架構如附件四。目前 ASEANET 主要的活動是推動亞太地區性病蟲害鑑定技術訓練工作以及開發診斷用電腦輔助系統，以提升診斷鑑定水準。

㈤各國報告資料之分析討論

由各經濟體代表的報告中可歸納出目前被各國公認較重大的

病蟲害共包括十八種，分別為果實蠅類(Fruit flies)、薊馬(Thrips)、粉蝨類(Whiteflies)、潛葉蠅及潛葉蛾(Leafminers)、斑潛蠅(*Liriomyza* sp.)、蟎類(Mites)、線蟲類(Nematodes)、細菌性萎凋病(Bacterial wilt)、柑桔黃龍病(Citrus greening)、Fusarium 萎凋病(Fusarium wilt)、露菌病、南美葉枯病(South American leaf blight)、炭疽病類(Anthracnoses)、香蕉萎縮病、木瓜輪點病(Papaya ring spot virus)、棕櫚類頂死病(Coconut Cadang-cadang viroid)及簇葉病(Witches' broom)。而各經濟體在病蟲害鑑定上所面臨之主要問題則包括：1.缺乏國外病蟲害資料，包括鑑定用檢索表或文獻等。2.難以取得各國的病蟲害清單資料。3.文獻及標本蒐集不全。4.缺乏鑑定專家。5.無法得到足夠的訓練，尤其是先進的分子生物診斷技術。6.缺少細菌學及線蟲學專家。7.與其他國家診斷機構間之資料交換及合作研究不足。8.認為目前所做的診斷試驗及基準(Protocol)的可信度或正確度不足。9.偵測特定病蟲害用之抗血清及 PCR 引子等材料缺乏。10.缺乏足夠的實驗室或設備。針對上述問題，經與會代表的充分討論，獲致未來能組成團隊以加強跨經濟體間的合作研究、促進文獻交流、聯繫、建立重要病蟲害清單、地區性共同標準以及新入侵或截獲病蟲害資料之分享等多項的建議。

㈥澳洲的植物病蟲害調查及監測體系報告

1.澳洲北部病蟲害診斷網(NADN)

於一八九八年成立，其主要任務為執行定期性病蟲害監測、偵測及預警工作，目前除已經在澳洲北部從肯因茲到布隆(Broome)的沿線地區間執行該些措施外，亦支援其鄰進國家，如巴布亞新幾內亞等，進行相關之病蟲害合作監測研究計畫。而在分子生物診斷鑑定技術開發方面，NADN 近幾年亦已獲致很好的成果，例如近兩年來該診斷網已陸續開發出香蕉細菌性萎凋病(Blood disease)、柑桔黃龍病、水稻 Tungro 病(Rice tungro)、香蕉葉斑病(Banana Sigatoka)、香蕉條紋病(Banana streak)、柑桔潰瘍病(Cutrus canker)及一種樹(*Planchonia careya*)的簇葉病的 PCR 快速鑑定方法。

2.果實蠅監測體系

早在一九七六年澳洲北部即已開始進行果實蠅的監測計畫，到了一九八〇年代，其監測的範圍更持續擴大，並且成為澳洲北部地區檢疫上的一個重要計畫項目。因此當一九九五年該系統偵測到木瓜果實蠅(Papaya fruit fly)入侵到肯因茲地區時，有關的監測及緊急防治工作即能迅速展開，並將其有效的控制及撲滅。目前在澳洲昆士蘭仍繼續設置有一四〇個果實蠅的調查點，並配置有四二〇個誘蟲器，持續進行果實蠅的長期性監測工作。除在澳洲國內之監測計畫外，澳洲國際農業研究中心(ACIAR)自一九九五年起亦支助在南太平洋二十一個島嶼國家進行果實蠅之監測工作，總共設置有一九四〇個誘殺器。該項監測工作係由經過訓練的當地專家來協助進行。此外，在 AusAID 的經費支助下，目前澳洲政府亦支助巴布亞新幾內亞進行其國內檢疫上重要果實蠅的長期監測工作。澳洲政府並期望能借助對其鄰國在病蟲害監測上的協助，可在國外建立起果實蠅的防護牆，以更有效避免其入侵到澳洲。

3.森林病蟲害之監測

對於森林病蟲害相關的防治及風險分析工作在亞太地區向來並未被重視。雖然一九九七年至一九九九年間，在 ACIAR 的支助下，澳洲曾與印尼、馬來西亞、泰國及越南等國進行過尤加利樹及阿拉伯橡膠樹害蟲之調查合作研究計畫。而且利用該些調查資料目前澳洲亦積極進行害蟲風險分析工作，但案例仍十分稀少。鑒於森林病蟲害在各國的入侵成功及嚴重危害案例仍層出不窮，例如松材線蟲(Pine wilt nematode)在日本、韓國及中國大陸的肆虐；松杼蛾(Pine shoot month)在越南、中國大陸及菲律賓之猖獗發生；小蠹蟲(*Ips* spp.)在中國大陸、菲律賓及澳洲大量發生；中國大陸的亞洲長角天牛(Asian longicorn)入侵美國，以及最近澳洲在從中國大陸進口物品的木製托板上截獲其罹染松材線蟲(Pine wilt nematode)等。因此為保護亞太地區森林生態環境，對於森林重要病蟲害的偵測及研究亟需積極推動。

㈦植物病蟲害診斷技術概述

係由澳洲專家介紹各種病蟲害診斷技術之新進展方向。內容重點在闡明除古典的形態分類鑑定方法以外，由於 ELISA 及 PCR 技術的普遍開發及廣泛使用，使得病蟲害的診斷能既快速又正確的完成，而且利用 DNA 資料更可提高病蟲害診斷的精準度。同時由於診斷的方便性及正確性提高，亦連帶使農民在病蟲害防治上亦可發揮正確診斷、正確用藥及減少損失的目的。此外，由於檢疫上重要病蟲害的種類相當多，加上過去長期以來各國政府對於傳統的分類工作並不太支持，使得分類專家在各國均十分缺乏，因此不管是傳統分類或新的診斷鑑定技術均需要各國的通力合作研究，才能彌補相互間之不足。

在進入研討會決議討論前，大會特別安排由我國報告明(九十一)年 10 月預計在台北召開的「入侵病蟲害之偵測、監測及管制研討會」目前籌備的方向、主要活動之設計等內容（摘要如附件五）。由於在會議期間有關上述會議的相關內容本人已私下多次向各國代表交換意見，且獲澳洲的大力支持及協助，因此在該報告後，各國均認為該項研討會之召開至有意義，且對促進亞太地區防疫檢疫技術水準甚有助益。

肆、研討會決議

經由本研討會中各代表所提出的意見，大會共針對六項的議題進行最後綜合討論及結論。各議題之主要結論包括：

一、診斷設備及需求之評估：建議再設計一份詳細的問卷進行各經濟體在軟硬體需求上的調查，預計於二〇〇一年年底前完成，並在亞洲網（ASEANET）下建置相關資料。

二、文獻蒐集：各經濟體代表均認為病蟲害文獻電子化及網路化將為未來資料交流上必然之趨勢，因此建議由 ASEANET 及澳洲的 CSIRO 先協助規劃並草擬出架構，並送交各經濟體提供意見，並預計於二〇〇一年十一月完成。

三、資訊交流：為加強 APEC 經濟體間之資訊交流，各國代表認為

有必要建置一個區域間的網路討論群(Listsever)，以分享各種疫情及技術資訊。建議參考目前已設置的病蟲害網(PESTNET)為藍本進行建置。另外在 ASEANET 上，未來亦可增加建置病蟲害診斷技術資訊及各經濟體病蟲害診斷鑑定專家名單，以方便聯絡。

四、主要病蟲害清單：為開發亞太地區重要病蟲害診斷技術，極有需要建置各經濟體間之主要病蟲害清單，以利本地區間合作研究之推動。在推動上，短期內可先列出少數幾種重要病蟲害清單，未來再繼續擴充。而各經濟體目前所共同關切的果實蠅合作研究則可優先予以納入。

五、地區性標準：為調和各經濟體間之檢疫措施，建立病蟲害診斷鑑定標準程序至有必要，例如地區性果實蠅診斷基準等。同時為落實該基準之使用，建議未來也將該些基準提送亞太地區植物保護組織(APPPC)，由其制定為國際標準。(下一次亞太地區植物保護組織會議將於二〇〇一年九月於越南召開，澳洲已表示將把此次研討會之結論連同此項建議提出在該會議中討論。)

六、截獲病蟲害清單及新入侵病蟲害報告：為有效避免病蟲害之越境蔓延，各代表均認為極有必要依據各經濟體的新入侵病蟲害資料建立全區性病蟲害預警網路。同時鑒於雖然診斷能力為病蟲害管理上一個很重要的環節，但是各代表亦同意推動區域間重要病蟲害的監測及緊急防治亦為另一項重要的主題，由於在本次研討會未能涵蓋，因此，建議該項議題能在二〇〇二年十月中華台北所舉辦的下一次工作小會議或研討會中加以詳細探討。該次會議所做總結報告詳如附件六。

伍、心得與建議

本次奉派參加會議除對我國目前病蟲害管制上有關診斷相關議題向大會作報告外，亦在大會協助安排下對我國爭取在二〇〇二年十月主辦下一場研討會之內容向各經濟體說明其具體的重點內容及方向，並普獲各代表的支持。由於我國即將主辦的研討會被大會視

為是本次研討會的一個向下延伸的會議，所以大會亦給予諸多的協助與指點。針對參加本次會議所獲心得及建議事項如下：

一、在動植物檢疫技術上我國在 APECWG 動植物檢疫分組中向來具有技術領先之優勢，各經濟體不管之前有無與我國有過合作研究關係，對於我國相關技術之發達均給予肯定，並希望與我加強技術合作。透過本項會議的交流，除可有效掌握國際植物檢疫及病蟲害管理相關重要訊息外，亦能與各國代表加強交流，因此派員與會甚具意義，未來應繼續派員參加。

二、本次會議在澳方的精心安排下運作十分順利。由於我國將舉辦下一次的會議，鑑於此項會議係屬於工作小組性質之會議，與一般傳統之國際會議有別，其主要是著重在由與會代表進行腦力激盪，發掘問題及提出解決對策，並於作成最後總結後，訂定出重點工作目標及提出預定完成時間表，所獲成果並須作成綜合報告提報給 APECWG。因此本次與會之另一項任務是學習如何以同樣模式為我國舉辦下一次會議，對提昇我國舉辦類似國際性 APECWG 會議之經驗及能力至有幫助。

三、我國對於 APEC 各會員國間的農業技術合作以往已建立有很好的管道，例如亞太糧肥中心及亞洲蔬菜研究發展中心所提供的技術指導、訓練及經費支助均普獲各國的肯定。但就整體而言，我國與 APEC 經濟體間之植物防疫檢疫合作研究仍屬十分欠缺，為有效管制國外病蟲害之入侵，建議今後可加強與 APEC 經濟體間的病蟲害監測、管制方法及技術上加強合作研究與交流，其優點除可共同開發相關技術外，也可循澳洲協助其鄰近國家加強病蟲害監測及鑑定之模式及經驗，掌握國外疫情及建立國外的病蟲害防護牆。

四、由於舉辦類似的國際性研討會除可促進地區間之農業科技發展與交流外，藉由會議的召開，主辦國更可蒐集到各國的防疫檢疫資訊及病蟲害疫情，同時由於透過與國際相關單位間的聯繫，可獲得國際間的更多的支援，並對帶動亞太地區間之相關技術發展也取得主導的地位。因此，建議及早詳細規劃我國將舉辦之下一次 APEC 研討會相關事宜，並寬列經費辦理。

五、國際植物病蟲害疫情之交流已朝向電腦化及網路化，透過網際網路傳遞重要病蟲害疫情已為未來必然之趨勢。我國的電腦科技及植物疫情管制相關技術目前已相當先進。惟為符國際化及普及化之趨勢，建議加強研擬建置亞太地區或東亞地區植物疫情網之規劃，或可參與 BioNET 之一部份，以更主動積極的方式取得國際間疫情網路建置及管理上之優勢及資源。

附件一、參加會議之各國代表名單

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附件二、研討會議程及活動內容

Tuesday 3 July 2001 (Day 1)

0800 Coffee and registration

Session 1 – Plant Health Issues in the APEC Region
Chair: Dr Mike Cole (AFFA)

0830 Issues of regional security
Dr Bill Roberts (AFFA)

0900 Welcome and introductory remarks
Prof John Irwin (CRCTPP)

0930 Overview of the USA biosafeguarding review
Prof Gordon Gordh (USDA)

1000 Morning tea

Session 2 – Country Reports
Chair: Dr Banpot Napompeth (ASEANET)

1030 Chinese Taipei *(Mr Horng-Yih Chang)*
Hong Kong *(Mr Koon-wang Wong)*
Indonesia *(Dr Sri Suharni Siwi)*
Japan *(Dr Etsuo Kimishima)*
Korea *(Dr June-Yeol Choi)*
Malaysia *(Mr Ho Haw Leng)*
PNG *(Dr David Tenakania)*
People's Republic of China *(Mr Yuxi Wang)*
Philippines *(Dr Bonifacio Cayabyab)*
Singapore *(Dr Choi-Pheng Yik)*
Thailand *(Mr Komsan Jumroonpong)*
Viet Nam *(Ms Phan Thanh Hang)*

1230 Lunch

Session 3 – Assisting Developing Economies in SPS-Related Matters
Chair: Dr Keng Yeang Lum (ASEANET)

1330 Summary of country reports
Dr Banpot Napompeth (ASEANET)

1355 Plant health as a trade policy issue
Dr Cheryl McRae (AFFA)

1420 Regional activities in diagnostics and related research
Dr Paul Ferrar (ACIAR)

1445 Convention on Biological Diversity and environmental issues
Dr Ian Cresswell (Environment Australia)

1510 Afternoon tea

Session 4 – Networking Activities for Regional Development in Plant Health
Chair: Dr Paul Ferrar (ACIAR)

1530 Australian networking activities
Dr Ian Muirhead (CRCTPP)

1550 New approaches and technologies for plant pest diagnostics in Australia
Dr Rob Floyd (CSIRO Entomology)

1610 Activities in the South Pacific region
Dr Jacqui Wright (SPC)

1635 ASEAN network
Dr Keng Yeang Lum (ASEANET)

1700 Diagnostics and biosystematics
Dr Jane Moran (Agriculture Victoria)

1720 Session close

1800 Workshop function (BBQ Dinner)

Wednesday 4 July 2001 (Day 2)

Session 1 – Analysing Country Reports
Chair: Dr Bill Roberts (AFFA)

0830 Working groups (4)
Facilitators: Dr Ian Naumann, Dr Nguyen Van Tuat, Dr Jacqui Wright and Dr John McDonald

0930 Reporting of group findings by facilitators

1000 Morning tea

Session 2 – Regional Surveys
Chair: Dr Mike Cole (AFFA)

1030 AQIS/NAQS surveys
Dr Richard Davis (AQIS)

1100 Fruit fly surveillance in the region
Prof Dick Drew (Griffith University)

1130 Forest pest surveys
Dr Ross Wylie (QDPI Forest Service)

1200 Lunch

Session 3 – Overview of Diagnostic Science
Chair: Dr Jacek Plazinski (AFFA)

1300 Overview of diagnostic techniques
Dr Margaret Schneider (CRCTPP)

1310 Diagnostic services for plant industries
Dr Peter Merriman (DNRE)

1330 Diagnostic delivery platforms
Dr Felice Driver (C-Qentec Diagnostics)

1350 DNA-based diagnostics of insects
Mr Glenn Graham (UQ)

1410 Quarantine bacterial pathogens
Dr Mark Fegan (CRCTPP)

1430 Afternoon tea

Session 4 – Short Field Trip

1500 Depart Bardon Centre and travel to the Queensland Department of Primary Industries laboratory at Indooroopilly

1530 Mycology collection and database
(Dr Roger Shivas)

1545 Molecular diagnostics laboratory
(Drs Dennis Persley, Andre Drenth, Suzy Bentley, and Juliane Henderson)

1620 Lucid demonstrations
(Prof Geoff Norton and Dr David Walter)

1700 Depart Indooroopilly

1715 Arrive Toowong central – delegates to choose dinner for themselves and return to the Bardon Centre by taxi

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Thursday 5 July 2001 (Day 3)

1 Day Field Trip

0830 Depart Bardon Centre

1000 Arrive at the Big Pineapple – delegates to purchase morning tea and sightsee

1045 Depart the Big Pineapple

1100 Arrive Maroochy Research Station, Nambour

1115 Introductory talk in conference centre

1200 Lunch

1300 Inspection of Research Station

1500 Depart Nambour for Brisbane via Mapleton with a brief stop at Mary Cairncross Park for afternoon tea

1730 Arrive Bardon Centre

Friday 6 July 2001 (Day 4)

Session 1 – Developing a Regional Program to Build Diagnostic Capacity
Chair: Dr Ian Naumann (AFFA)

A workshop session providing delegates with an opportunity to formulate a collaborative work program

0830 Working groups (4)
Facilitators: Dr Rob Floyd, Dr Keng Yeang Lum, Dr Choi-Pheng Yik and Dr Banpot Napompeth

1040 Reporting of group findings by facilitators

1100 Morning tea

Session 2 – Formulating Workshop Recommendations
Chair: Dr Bill Roberts (AFFA)

1130 Final summary
Workshop recommendations
Closing remarks

1230 Lunch

Workshop close

附件三、我國所發表之報告內容資料

Diagnostic Services of Plant Pests in Chinese Taipei

Horng-yih Chang
Bureau of Animal and Plant Health Inspection and Quarantine, Council of Agriculture

In as early as 1988, because of the concerns of possible invasion of exotic plant pests from other parts of the world to Taiwan, the Council of Agriculture (COA) of Chinese Taipei had initiated the program 'Diagnosis and Identification of Invasive Plant Pests from Abroad'. Samples were routinely taken from imported agriculture products and sent to various designated diagnostic laboratories for identification. The results were sent for further analysis to the COA, which was responsible for domestic plant protection and quarantine policies and the former Bureau of Commodity Inspection and Quarantine (BCIQ), Ministry of Economic Affairs, which executed plant quarantine at ports. With the rapid increase in international agricultural trade, prevention and combat of damages caused by plant pests have aroused greater concern. In 1998, the Bureau of Animal and Plant Health Inspection and Quarantine (BAPHIQ) was established by the COA to consolidate administration in the policy making and execution of animal and plant health inspection and quarantine. The diagnostic aforementioned program was then re-structured and expanded to meet the current need.

With the help of computer networking, information delivery and distribution have become easier and cost less. This has been very helpful in enhancing the service capabilities of the diagnostic laboratories. The diagnostic clinics were expanded to include administrative personnel, plant pathologists, entomologists and extension scientists. Training courses have been given annually to related personnel for upgrading computer-networking skills. A scheme of the networking is shown in Figure 1. Report of monitoring and identification of pests are to submit to the checkpoints of the network system through Internet. Detail of these checkpoints is as follows:

Center for information management: The center is located in the headquarter of the BAPHIQ and is in charge of managing and archiving pest information that is delivered from local diagnostic clinics. All information is transferred through Internet and updated daily. The center is also in charge of risk assessment, strategy making, and news release.

Local information center: County-level information center is located in each of the 8 district agricultural improvement station (DAIS), which is in charge of collecting all pest-related information within its responsible counties. The local information center is set up in order to monitor potential pests and assist in preventing specific disease or pest from outbreaking.

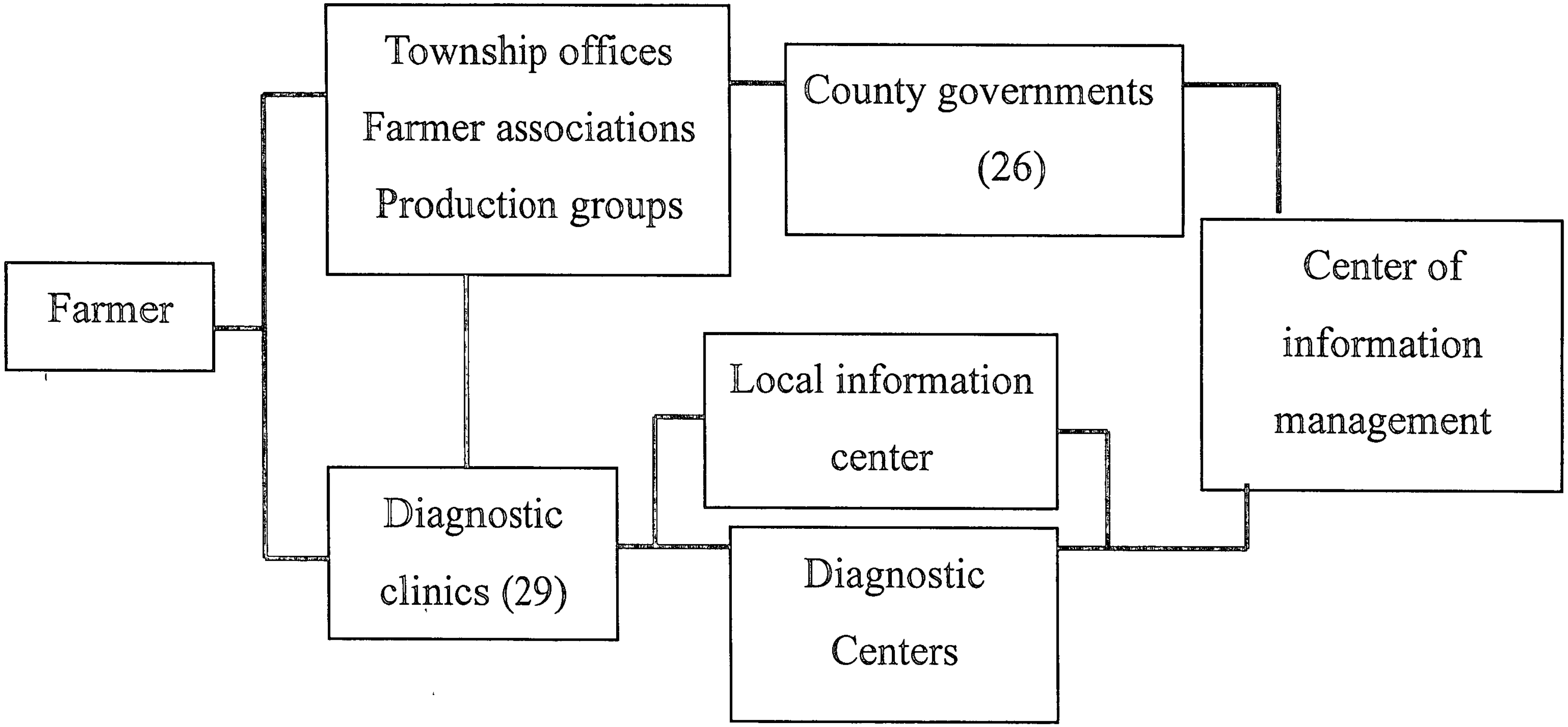
Center for pest identification: The center is located in the Taiwan Agriculture Research Institute (TARI). In addition, related universities such as National Taiwan University, National Chung Hsing University, National Chia-yi University and National Ping-tung University of Science and Technology are also in coordination with TARI in pest identification. About 40 taxonomic experts in entomology and plant pathology take part in the identification works, and their laboratories are all well equipped. The Center also assists diagnostic clinics in the identification of plant pests. Collection of specimens of plant pathogens and economic insects is located in TARI.

Diagnostic clinics: A diagnostic clinic was firstly established in Taiwan Agriculture Chemicals and Toxic Substances Research Institute in 1982. Since then, 29 clinics located in the DAIS and related research institutions were established subsequently. Each clinic has an extension plant pathologist or entomologist in charge of diseases and pest diagnosis and answering questions from growers as well as assisting or supervising in pest control. The clinical expert would send diagnostic report of each case through Internet to the center for information management (BAPHIQ) for further data analyses. Each year the clinics collectively received about three thousand diagnostic cases and have been proven very functional in uncovering newly invading pest species.

In regard to the monitoring system, a list of pests is designated under consistent nation-wide surveillance. The important monitoring systems are for the oriental fruit fly, melon fly, tobacco cutworm and beet army worm which are all under nation wide surveillance. Diagrams for population dynamics of each pest are posted on the TARI Web site every ten days, and alarms will be made if the population density is over the economic threshold. Besides, other thirty-three pests are also put under surveillance by local information centers to meet local interest.

The annual budget for operating the system is about US$ 3.26 million. As many as 150 scientists are involved. In order to make the system more efficient, the BAPHIQ is planning to recruit growers and pesticide wholesalers and retailers who have interest in joining in pest surveillance program, thus expanding the scope of the monitoring system.

Figure 1. Diagram of diagnostic service in Taiwan



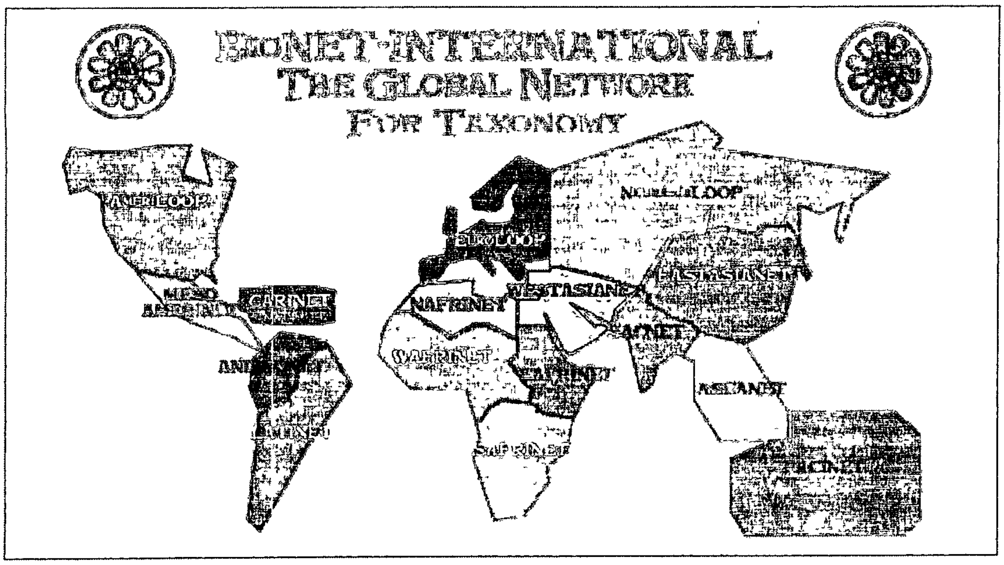
附件四、全球生物網(BioNet)之分支架構

BioNET-INTERNATIONAL, the Global Network for Taxonomy, is a world-wide, inter-governmental initiative for capacity building in taxonomy (biosystematics) in developing countries. BioNET-INTERNATIONAL is dedicated to enabling developing countries to achieve realistic self-reliance in the skills of identifying and. understanding the relationships of the different organisms which constitute our living environment. It is comprised of sub-regional LOOPs (Locally Organised and Operated Partnerships) of developing country institutions, supported by a consortium of developed country institutions (BIOCON), and managed by its Technical Secretariat (TECSEC).

Its purpose is to enable developing countries to achieve realistic self-reliance in taxonomy to support regional and national programmes for eradication of poverty, via sustainable use of natural resources and agricultural development,and conservation of biodiversity (including implementation of the Convention on Biological Diversity).

Locally Organised and Operated Partnerships, i.e. sub-regional Technical Cooperation Networks (TCNs) of relevant taxonomic institutions.

There are at the present time LOOPs in the Caribbean (CARINET), East, West and southern Africa (EAFRINET, WAFRINET and SAFRINET respectively), South East Asia (ASEANET), South Pacific (PACINET) and Europe (EuroLOOP) - a total of 120 countries. Others are currently being developed in East Asia, West Asia, South Asia and the Andean sub-region.



附件五、我國爭取舉辦之下一屆研討會內容草案

Proposal for APEC Workshop on Detection, Monitoring and Management of Invasive Plant Pests

Objective:

To encourage cooperation among APEC member economies:

- to prevent the introduction and spread of invasive plant pests
- to improve the technologies on detection, monitoring and emergency control of invasive plant pests
- to enhance the collaboration on the computerized network information system of invasive plant pests

Tentative dates: Oct, 2002 (4 days, include a one day field trip)

Venues: Taipei and central Taiwan

Hosted by:

Bureau of Animal and Plant Health Inspection and Quarantine, Council of Agriculture, Chinese Taipei

Participants:

Government officials, experts of relevant research institutes, and university faculty from APEC member economies

Activities:

1. Presentation on invasive plant pests issue
   ① Concept of invasive plant pests
   ② Agricultural, environmental and ecological impact of invasive species
   ③ Coordination of relevant authorities and organizations on prevention and control of invasive species
2. Presentation on monitoring network system (case studies- Chinese Taipei and other member economies)
3. Report of member economies
   Methodologies and technologies employed for detection, monitoring and control of invasive plant pests, and administrative management.
   ① Pest surveillance including collection, storage, retrieval and use of information, and technologies used for sampling, monitoring, detection and identification
   ② Effective measures for emergency control
   ③ Relevant authorities and organizations involved in the control of pest

and their coordination activities

④ Sources of budget for control

4. Discussion on the establishment of networking activities among APEC member economies for regional development in invasive pest detection, monitoring and emergency control

   ① Overview of new approaches for invasive pest detection, monitoring and emergency control information system in the region

   ② The establishment of information network system for monitoring, detection, and early warning of specific invasive plant pests, and distribution of information

   ③ Coordination among member economies for emergency control

   ④ Assistance in technology development

5. Field trip to central Taiwan areas

   ① Visits to research institutes and universities

   ② Observation of the pest monitoring and control

附件六、澳洲舉辦本次會議之總結報告

APEC Workshop to Contain Transborder Movement of Plant Pests: Diagnostics
3-6 July 2001 Brisbane, Australia

A Report to the Agricultural Technical Cooperation Working Group by the Organising Committee

INTRODUCTION

This paper reports on the content, outcomes and recommendations of the APEC Agricultural Technical Cooperation Working Group (ATCWG) *Workshop to Contain Transborder Movement of Plant Pests: Diagnostics* held in Brisbane 3-6 July 2001. This is the fifth workshop of the ATCWG's sub-group on Plant and Animal Quarantine and Pest Management and the fourth with a plant health focus. Previous workshops were held in Honolulu, Cairns and Kona; the former two with a focus on pest risk analysis and the latter looking at opportunities for alternatives to methyl bromide as phytosanitary treatments for commodities in trade. A fourth workshop held in Brisbane in 2000 was for animal health scientists.

This workshop was an initiative of the Office of the Chief Plant Protection Officer (OCPPO), Agriculture Fisheries & Forestry - Australia and the Cooperative Research Centre for Tropical Plant Protection (CRCTPP), with generous financial support provided by the Australian Agency for International Development (AusAID) and the Australian Centre for International Agricultural Research (ACIAR). The workshop program was developed by staff of the OCPPO in consultation with officers in the CRCTPP and Biosecurity Australia.

The Organisers of this workshop sought to focus the attention of the ATCWG's sub-group on Plant and Animal Quarantine and Pest Management on the capacity of regional plant health services to provide rapid and accurate diagnosis of plant pests and pathogens. The Organising Committee did this believing that the capacity of some APEC economies to undertake market access negotiations for agricultural commodities may be constrained by deficiencies in the basic infrastructure underpinning plant health. Issues of concern include:

- Access to accurate diagnostic tools and expertise;
- Difficulties in accessing records of endemic pests/diseases lodged in collections both within Member economies and elsewhere;
- The level of resources allocated to taxonomic work in collections holding arthropod pests and plant pathogens;
- The security of biological collections; and
- The lack of a coordinated strategy for managing these resources.

It was against this background that the Organising Committee framed a workshop program on diagnostics for plant pests and pathogens, with the following objectives:

- Identify priority plant pests for the region and gaps in each economy's capacity to detect and manage these pests with a view to developing diagnostic resources to address specific needs.

- Determine the availability and size of biological collections and databases or other information management systems in each economy and the capacity of economies to access and manage data on their plant health status.

- Improve cooperation between APEC economies to manage information on plant pests with a view to developing a regional diagnostic and information exchange network for priority pests.

ATTENDANCE

The workshop was attended by 44 delegates from 16 APEC economies. A list of delegates is at Attachment 1.

WORKSHOP PROGRAM

The workshop was held over three and a half days and included formal papers, working group sessions and two field trips (see program at Attachment 2). The latter included visits to a research facility and field station belonging to the Queensland Department of Primary Industries where delegates were given the opportunity to discuss molecular diagnostic techniques, information management systems (LucID) and current work on the biological control of plant pests.

The workshop program provided an opportunity to inform delegates of the role of plant health in trade policy, and highlighted the fact that countries must know their plant health status if they are to meet their obligations for science-based risk assessment under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement). It was emphasised that, in the context of international trade, there is an important difference between the status of a pest or pathogen that is 'not known to occur' in a country, and one that is 'known not to occur' based on diagnostic capacity, validated reference collections, and surveillance/monitoring systems.

Attention was also given to issues of regional security. Dr Bill Roberts (Australia) noted that cooperation is vital to minimize transborder movement of plant pests and improve regional plant health capacity. Areas for cooperation can be placed under four headings:

- Prevention – quarantine/biosecurity systems (pest risk analyses etc).
- Preparedness – surveillance, diagnostic capacity, training, information exchange, regional contingency plans.
- Response – access to diagnostic tools and expertise, control technology, cost-benefit analysis, field assistance.
- Recovery – enhanced capacity, on-going management systems.

Several speakers noted that diagnostic capacity has implications for national biosecurity, facilitation of trade, and biodiversity. On the issue of networking, delegates recognised that networks are crucial because the task of defining a country's plant health status is too large and costly for any single organisation, but that there is a need for an organisational framework to implement regional cooperation. It was suggested that ASEANET[1] could be such a framework.

Participating economies were encouraged to exchange information on their capacity to diagnose plant pests and pathogens and to manage plant health data. Each economy was asked to complete a questionnaire prior to the workshop, covering such matters as:

- regulatory structure for plant health and quarantine in each economy;
- availability of diagnostic services, tools and protocols;
- priority pests/pathogens;
- key contacts for information; and
- constraints and needs in plant health diagnostics.

Completed questionnaires were distributed to workshop delegates in Brisbane. During Session 2 on Day 1, delegates from Chinese Taipei, Hong Kong, Indonesia, Japan, Korea, Malaysia, Papua New Guinea, People's Republic of China, Philippines, Singapore, Thailand and Vietnam reported to the group on the key issues identified in the questionnaire. Common difficulties in diagnosing important plant pests and pathogens experienced by the participating economies were:

- Access to information (keys and scientific literature) on exotic pests/pathogens;
- Access to pest lists (information on the economy's plant health status);
- Poor status of reference collections (biological specimens);
- Limited technically skilled staff;
- Access to appropriate training (especially for upgrading skills, for example, in the use of molecular diagnostic techniques);
- General lack of specialists (in fields such as bacteriology, nematology etc);
- Information exchange/networking mechanisms for collaborating with various national and regional diagnostic institutions;
- Reliability/accuracy of current diagnostic tests and protocols;
- Availability of antisera/primers for detecting specific pests/pathogens; and
- Availability and maintenance of laboratory facilities.

In Session 1 on Day 2, delegates were asked to break into four working groups to consider these issues, giving particular attention to: major gaps; general needs; specific country needs; and opportunities for addressing identified needs. The findings of the working groups are summarised at Attachment 3.

During Sessions 1 and 2 on Day 4 delegates explored mechanisms for plant health scientists to collaborate on common problems and bring forward recommendations for actions to improve the management of plant health on a regional basis. Initiatives identified for inclusion in a work program were aggregated under the following headings: diagnostic capacity and needs assessment; reference collections; communications; target lists; regional standards; and interception data/incursion reports.

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[1] ASEANET is the South East Asian LOOP of BioNET-INTERNATIONAL, a technical cooperation Network for sustainable development through capacity-building in taxonomy.

WORKSHOP OUTCOMES AND RECOMMENDATIONS

Diagnostic Capacity and Needs Assessment

Delegates recognised that although the questionnaires and country reports presented at this workshop provide some indication as to the gaps in regional diagnostic capacity, there is an urgent need for a comprehensive assessment of current capacity and needs, both in terms of diagnostics and reference collections, before a strategic plan of action can be formulated. It was agreed that the survey of regional institutions holding collections of plant pathogens, to be conducted under the umbrella of ASEANET in Sept/Oct this year[2], is an important starting point, but that the activity should be complemented by similar initiatives for arthropod pests and weeds. Delegates supported the development of a regional questionnaire which would seek information on the status of both diagnostic expertise and collections, and agreed that this activity should be completed ahead of the next meeting of the working group to be hosted by Chinese Taipei in October 2002.

Recommended Actions

1. Design a detailed questionnaire/survey of current diagnostic capacity and needs. The survey should seek information on:

    - diagnostic capacity for plant pests, pathogens and weeds (where appropriate, the survey should distinguish between capacity to perform original systematic research and more routine diagnostic capacity);
    - available tools and expertise;
    - ability to assist other economies;
    - type of training that can be provided; and
    - sustainability of capacity, skills and programs.

    The survey should also seek information on the status of reference collections of plant pathogens, arthropod pests and weeds, giving particular attention to:

    - host institutions;
    - collection size;
    - taxonomic, geographical and commodity coverage;
    - access and usage (locally and by international specialists);
    - data management;
    - security (statutory protection);
    - staffing; and
    - management priorities.

2. Distribute survey to all regional APEC economies. Compile and analyse survey data before the end of 2001.

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[2] This activity is supported by AusAID under the AusAID APEC Support Program.

3. Build a web-based summary of diagnostic capacity (eg. under the ASEANET website).

Delegates noted that the Australian Plant Pest and Disease Diagnostic Service Survey could be used a model, but would need to be expanded to cover reference collections and weed-related issues. Australia (Office of the Chief Plant Protection Officer) undertook to coordinate this activity, with assistance from Dr Rob Floyd, Dr Ian Muirhead, Dr Glenn Graham, and Dr Keng Yeang Lum. It was agreed that the survey would be sent initially to workshop delegates, who would then circulate it to the relevant officers/institutions in their economy. Delegates agreed that this activity should be pursued as a matter of priority.

Reference Collections

There was consensus that all APEC economies would benefit from improved access to verified specimens and other information held in reference collections since, in the context of international trade, these are only acceptable records of pests that are known to exist within a country. Delegates indicated that the feasibility of adopting specialist databases to make the records of pests and pathogens available electronically and linked via the Internet needs to be explored in further detail and should be the subject of another workshop.

Delegates recognised that a significant amount of work is required to validate existing plant pest and disease records and ensure their security. It was agreed that there is a need to seek out opportunities for funding the rehabilitation of collections held in regional institutions[3]. Resources for this activity should be a combination of external funds from donor agencies and internal sources.

Recommended Actions

1. Generate a comprehensive list of agencies that might provide resources for collection rehabilitation, noting current and potential funding sources and the types of activities that these organisations have supported previously.

Dr Lum of ASEANET and Dr Floyd of CSIRO Entomology undertook to compile an initial list, which would then be circulated to workshop delegates for their input and comments. Delegates agreed that this activity could be completed by November 2001.

Communications

Delegates endorsed the establishment of a listserver for plant health and agreed that this would be the most effective means of reaching plant health specialists and diagnosticians in the region on a regular basis. The purpose of the listserver would be to help plant health specialists share information, but delegates recognised that it would require a strong commitment from participating economies if it is to be fully

[3] The OCPPO has received funds from AusAID under the Indonesia Australia Government Sector Linkages Program for the development a database and upgrading of associated reference specimens of agriculturally important insects at the Central Research Institute for Food Crops, Bogor, and the Museum Zoologicum Bogoriense, Cibinong.

effective. Dr Banpot Napompeth reminded delegates that a key challenge is to ensure the sustainability of information exchange networks.

There was consensus that an Internet-based 'clearing house' for information on priority pests and pathogens, diagnostic tools and techniques, and training would be extremely useful and could be located on the ASEANET website. Delegates agreed that in order to develop such a resource, it is essential to have a good understanding of current regional capacity (strengths and weaknesses). The outcomes of the regional survey could be used to initiate this activity.

Recommended Actions

1. Establish a listserver for plant health in the South East Asian region, using PESTNET[4] as a model.

2. Provide the ASEANET website with information on diagnostic tools and expertise available in regional economies. The outcomes of the regional survey of diagnostic capacity could be made available on the ASEANET website.

The OCPPO, in collaboration with ASEANET (Dr Lum and Dr Banpot Napompeth), undertook to explore mechanisms for setting up the listserver. It was agreed that the listserver would function as a general communication mechanism for this Working Group to progress other activities and should be established as a matter of priority. All workshop delegates would initially be subscribers to the listserver. Subscription would be free and open to anyone with an interest in this area.

Target Lists

On considering the need for the development of new diagnostic tools and improving access to existing tools, delegates agreed that there is a real need to set priorities for the region. Diagnostic tools may be conventional, molecular or both – Dr Paul Ferrar stressed that although many economies frequently request training in molecular techniques, the importance of conventional skills, such as how to survey, collect and curate specimens, should not be overlooked.

It was suggested that a regional target list should be developed and that 3-4 priority pests, pathogens, weeds and/or commodities be selected from this list for use as case studies for regional collaboration.

Recommended Actions

1. Refine the draft target list with a view to identifying 2-3 other priority pests/pathogens/weeds/commodities that could be used as case studies for progressing a collaborative regional work program.

2. Prepare a framework for collaboration on fruit fly pests of concern to regional economies.

[4] PESTNET is a listserver that has been established for the Pacific region to facilitate the informal exchange of information on plant pests and diseases.

The OCPPO undertook to circulate the draft target list of priority pests and pathogens extracted from the country reports/questionnaires to workshop delegates for further comment before finalising the list and selecting those to be used as case studies. It was agreed that the scope of the target list may need to be expanded to include nematodes, weeds and commodity groupings and that criteria for prioritising should be considered. Professor Dick Drew of Griffith University agreed to draft a framework for fruit flies. Although a significant amount of information exists for these pests, delegates agreed that data on current activities, diagnostic tools and expertise need to be pulled together and a strategic plan for the region developed.

Regional Standards

It was agreed that there would be considerable benefit in the establishment of regional standards in the area of diagnostics, for example, a regional standard for fruit flies. Delegates were advised that any organisation or agency could propose the development of standards to the Asia Pacific Plant Protection Commission (APPPC) for consideration. Delegates agreed that the APPPC represents a useful umbrella for developing regional standards on plant health-related matters.

Recommended Actions

1. Australia (OCPPO) to prepare a report on the outcomes of this workshop for the APPPC. The report would seek in-principal support from the APPPC to develop a proposition for regional standards in diagnostics in the near future.

The next meeting of the APPPC will be held in September 2001 in Vietnam.

Interception Data and Incursion Reports

Delegates recognised that there is a need for improved management and recording of interception data, as this information is vital for use in reviewing existing procedures and improving biosecurity systems. The possibility of developing a regional pest alert network based on incursion data was also raised as a mechanism for improving preparedness across the region. Diagnostic capacity is a vital component of pest management strategies, but delegates agreed that it was beyond the scope of this workshop to develop a regional work program for strategies such as surveillance and eradication programs. It was suggested that these issues could be explored at the next meeting of the Working Group in Chinese Taipei in 2002.

Recommended Actions

1. Issues associated with the management of interception data and the reporting of incursions should be addressed in further detail at the next meeting of the APEC ATCWG sub-group on Plant and Animal Quarantine and Pest Management to be hosted by Chinese Taipei in October 2002.

Attachment 1: List of Delegates (略)

Attachment 2: Workshop Program(略)

Attachment 3: Working Group Findings

Preliminary target list of priority pests, pathogens and weeds:

Pests	Pathogens
◦ Fruit flies (several species)	◦ Bacterial wilt (several species)
◦ Thrips	◦ Citrus greening
◦ Whiteflies (several species)	◦ Fusarium wilt (several species)
◦ Leafminers (Diptera, Lepidoptera)	◦ Downy mildew
◦ *Liriomyza* spp.	◦ South American leaf blight
◦ Mites (several species)	◦ Anthracnoses (several species)
◦ Nematodes (eg burrowing nematode, *Radopholus similis*)	◦ Fire blight
◦ Citrus psyllids	◦ Papaya ring spot virus
	◦ Cadang-cadang viroid (coconut)
Weeds	◦ Ramu stunt virus
◦ *Salvinia molesta*	◦ Satsuma dwarf virus
◦ *Mimosa pigra*	◦ Banana bunchy top virus
	◦ Phytoplasmas (eg witches' broom)

Needs and opportunities:

Collections

Needs:
- Reference collections (virtual or real) of specific exotic groups
- Curation and maintenance of collections to ensure their security
- Verified country pest lists based on curated reference specimens

Opportunities:
- Address the curation and security of collections
  - seek funding to rehabilitate biological collections
  - commence a program of exchanging reference specimens of pests and diseases, with view to establishing comprehensive collections in selected institutions. Specimens could be exchanged permanently or on very long-term loan (e.g. for the working life of a specialist)

- Improve access to information held in reference collections
  - specimen database standardisation and training
  - networking of collection metadata within the region

Human resources

Needs:

- Hands-on training in diagnostics and eradication/control of exotics
- Training in molecular techniques, collection curation, general identification
- Sustainability/continuity of skills

Opportunities:

- To better utilise the skills/expertise that already exist in the region, except that we don't really know what exists!
  - conduct a comprehensive survey of current capacity and needs
  - technology transfer, for example, transfer of existing diagnostics tests for citrus greening and plum pox virus
- Develop regional training modules, or adapt existing courses, focused at an appropriate level to meet identified needs
  - stocktake of available training courses
  - consider a regional collaborative agreement on subsidised training

Diagnostics for important pests and pathogens

Needs:

- Taxonomic skills – specialist staff are limited
- More information on phytoplasmas
- Diagnostic tests for specific plant pests and pathogens
  - pests (eg. fruit flies, thrips, whiteflies)
  - pathogens (eg. papaya ringspot, bacterial wilt)
  - nematodes (eg. potato cyst nematode)
  - viruses (eg. banana bunchy top virus)
  - pictorial keys for weeds
- Fruit flies – most countries need better diagnostics of immature stages (molecular)
- Access to standard protocols (existing or new) and diagnostic keys
- Clearing-house of diagnostic protocols (and a register of specialists)
- Resolve fee-for-service issue

Opportunities:

- Develop a network directory of diagnostic expertise within (and also outside) the region
  - must be easy to use, access (electronic and paper versions) and update
  - searchable by commodity, host, pest/disease
  - utilise expertise across sectors

Networking / Information exchange

Needs:

- Networks for information exchange within and between economies
- Improved communication between Ministries of different sectors

-

Opportunities:

- Establish listserver for plant health in SE Asian region based on PESTNET model
- Consider how best to utilise ASEANET as a vehicle for information exchange

Regional pest and disease management

Needs:

- Skills in emergency response planning, pest surveillance and capacity to implement response measures
- Regional quarantine pest lists

Opportunities:

- Develop regional pest management strategies based on improved regional surveillance capacity

DAY 1 SESSION 1: PLANT HEALTH ISSUES IN THE APEC REGION

- **Issues of regional security**
  (Dr Bill Roberts, AFFA)

- **Welcome and introductory remarks**
  (Prof John Irwin, CRCTPP)

- **Overview of the USA biosafeguarding review**
  (Prof Gordon Gordh, USDA)

APEC Workshop to Contain Transborder Movement of Plant Pests:
Plant Health Issues in the APEC Region

Welcome and Introductory Remarks: Professor J.A.G. Irwin, Chief Executive Officer, CRC for Tropical Plant Protection, Brisbane, Australia

It is my great pleasure to welcome all participants to this APEC Workshop directed towards developing strategies to contain transborder movement of plant diseases and pests. As you may be aware, I am the CEO of the Cooperative Research Centre for Tropical Plant Protection (CRCTPP), which has a major focus on research, development and delivery of Disease and Pest Prevention outcomes. While the Centre's primary goal is to generate benefits for Australia, we need to take a global perspective in our research activities. A major challenge for this workshop is to take the CRCTPP model, and use it to shape a regional approach to containing disease and pest movement across borders.

To coordinate our disease prevention activities for northern Australia (north of 30°S), we have created a Northern Australian Diagnostics Network (NADN) under the umbrella of the CRC. All nine of the CRC's participants are members of NADN. The NADN has a role in prioritising diagnostics research for northern Australia, conducting research activities, coordinating the delivery of diagnostic outcomes, and in education and training as it relates to plant protection diagnostics. To underpin these activities, the CRCTPP and QDPI have constructed a state of the art molecular research laboratory at Indooroopilly, which you will be visiting later in the workshop.

All of northern Australia's plant-based industries are threatened by incursions of exotic pests, weeds and diseases, particularly from countries to Australia's north. It has to be remembered that with one or two exceptions, all of our economic crop species are introductions to Australia. This also includes a lot of our pathogen and pest species. There have been several recent Australian examples of incursions, viz. sugar cane smut, black Sigatoka of banana, tropical race 4 of Panama disease of banana, sorghum ergot, papaya fruit fly and several others. There is much we can do to take a more pre-emptive approach to minimising the risk of incursions of diseases and pests across borders.

As an example, through the activities of this CRC's predecessor (the CRC for Tropical Plant Pathology), DNA-based diagnostics had been pre-emptively developed for Panama tropical race 4, and were on hand to confirm, within 24 hours, suspected outbreaks in the Northern Territory. Quarantine containment strategies could then be expeditiously implemented, upon rapid confirmation of the presence of tropical race 4 using DNA-based technology. These are the obvious benefits from taking pre-emptive action to allow rapid diagnosis of quarantine pathogens and pests.

From an APEC perspective, there are several challenges which we face if we look at implementing the CRC approach on a regional scale. We need to:

- develop a coordinating mechanism which has, on a global scale, the same role as NADN.

- compile databases for each country. These databases should contain up-to-date pathogen and pest records. In all cases, validation of records is essential. An up-to-date database on currently available diagnostic tests for quarantine pathogens and pests is also needed.

- prioritise and research target pests. This will require research on etiology, diversity within the target species, developing a reliable and simple diagnostic test, and on incursion management strategies.

Through all of the above, there is a need to share knowledge and coordinate our activities, for mutual benefit.

This workshop will go a long way towards developing regional goals and strategies towards containing transborder movement of plant pathogens and pests. I wish everyone participating a mutually rewarding workshop.

Comments concerning US Plant Protection and Quarantine views on the role of Diagnostics in the Regional Movement of Plant Pests

Gordon Gordh, Director
Center for Plant Health Science and Technology
Animal Plant Health Inspection Service, USDA
Centennial Campus,
North Carolina State University
Raleigh, North Carolina 27606

Accurate identification (diagnosis) of organisms and plant diseases is fundamentally important to safeguarding agriculture in all countries. Quarantine services throughout the world cannot implement appropriate plans for dealing with potential pests until names have been authoritatively provided for the organisms and plant diseases that are involved. Accurate identification is necessary because all species have subtle differences in their biologies; these biological differences impact human activities, health and economics to various degrees. Formulating Quarantine Policy and Protocols against pests must be guided by accurate identification.

Accurate identification of potential pests is important to all countries and impacts all commodities. Over the past 30 years, the problem of accurate and timely identification has been exacerbated by an exponential increase in global travel and the internationalization of trade. APHIS is the agency within USDA that is charged with the responsibility of detecting invasive (exotic) organisms and dealing with them expeditiously. Recognition of exotic pests is a quarantine issue and thus falls within the area of responsibility of PPQ. The PPQ is very concerned with developing a regional strategy for diagnostics of exotic pests and diseases. We see that regional efforts are the first step toward global cooperation in pest detection and the tactical operations involved in eradication, containment or management.

Accurately identifying exotic pests demands communication and cooperation among nations or between trading and travel partners. To be effective in quarantine actions, we must share information such as nationally developed lists for all categories of plant pests – pathogens, nematodes, arthropods, weeds and insects. From our perspective we think that countries must share information on taxonomy and biology of taxa that are important to international safeguarding efforts. In addition, Pest Risk Assessments must be developed nationally and shared regionally. We also feel that an international list of taxonomic experts and their areas of specialty must be developed and maintained regionally.

DAY 1 SESSION 2: COUNTRY REPORTS

Presentations:

- Chinese Taipei *(Mr Horng-Yih Chang)*
- Hong Kong, China *(Mr Koon-wang Wong)*
- Indonesia *(Dr Sri Suharni Siwi and Antarjo Dikin)*
- Japan *(Dr Etsuo Kimishima)*
- Korea *(Dr June-Yeol Choi and Mr Young-Kee Lee)*
- Malaysia *(Mr Ho Haw Leng)*
- Papua New Guinea *(Mr David Tenakanai)*
- People's Republic of China *(Mr Wang Yuxi)*
- Philippines *(Dr Bonifacio Cayabyab)*
- Singapore *(Dr Choi-Pheng Yik)*
- Thailand *(Mr Komsan Jumroonpong)*
- Viet Nam *(Ms Hang Phan Thanh)*

Diagnostic Services of Plant Pests in Chinese Taipei

Horng-yih Chang
Bureau of Animal and Plant Health Inspection and Quarantine, Council of Agriculture

In as early as 1988, because of the concerns of possible invasion of exotic plant pests from other parts of the world to Taiwan, the Council of Agriculture (COA) of Chinese Taipei had initiated the program 'Diagnosis and Identification of Invasive Plant Pests from Abroad'. Samples were routinely taken from imported agriculture products and sent to various designated diagnostic laboratories for identification. The results were sent for further analysis to the COA, which was responsible for domestic plant protection and quarantine policies and the former Bureau of Commodity Inspection and Quarantine (BCIQ), Ministry of Economic Affairs, which executed plant quarantine at ports. With the rapid increase in international agricultural trade, prevention and combat of damages caused by plant pests have aroused greater concern. In 1998, the Bureau of Animal and Plant Health Inspection and Quarantine (BAPHIQ) was established by the COA to consolidate administration in the policy making and execution of animal and plant health inspection and quarantine. The diagnostic aforementioned program was then re-structured and expanded to meet the current need.

With the help of computer networking, information delivery and distribution have become easier and cost less. This has been very helpful in enhancing the service capabilities of the diagnostic laboratories. The diagnostic clinics were expanded to include administrative personnel, plant pathologists, entomologists and extension scientists. Training courses have been given annually to related personnel for upgrading computer-networking skills. A scheme of the networking is shown in Figure 1. Report of monitoring and identification of pests are to submit to the checkpoints of the network system through Internet. Detail of these checkpoints is as follows:

Center for information management: The center is located in the headquarter of the BAPHIQ and is in charge of managing and archiving pest information that is delivered from local diagnostic clinics. All information is transferred through Internet and updated daily. The center is also in charge of risk assessment, strategy making, and news release.

Local information center: County-level information center is located in each of the 8 district agricultural improvement station (DAIS), which is in charge of collecting all pest-related information within its responsible counties. The local information center is set up in order to monitor potential pests and assist in preventing specific disease or pest from outbreaking.

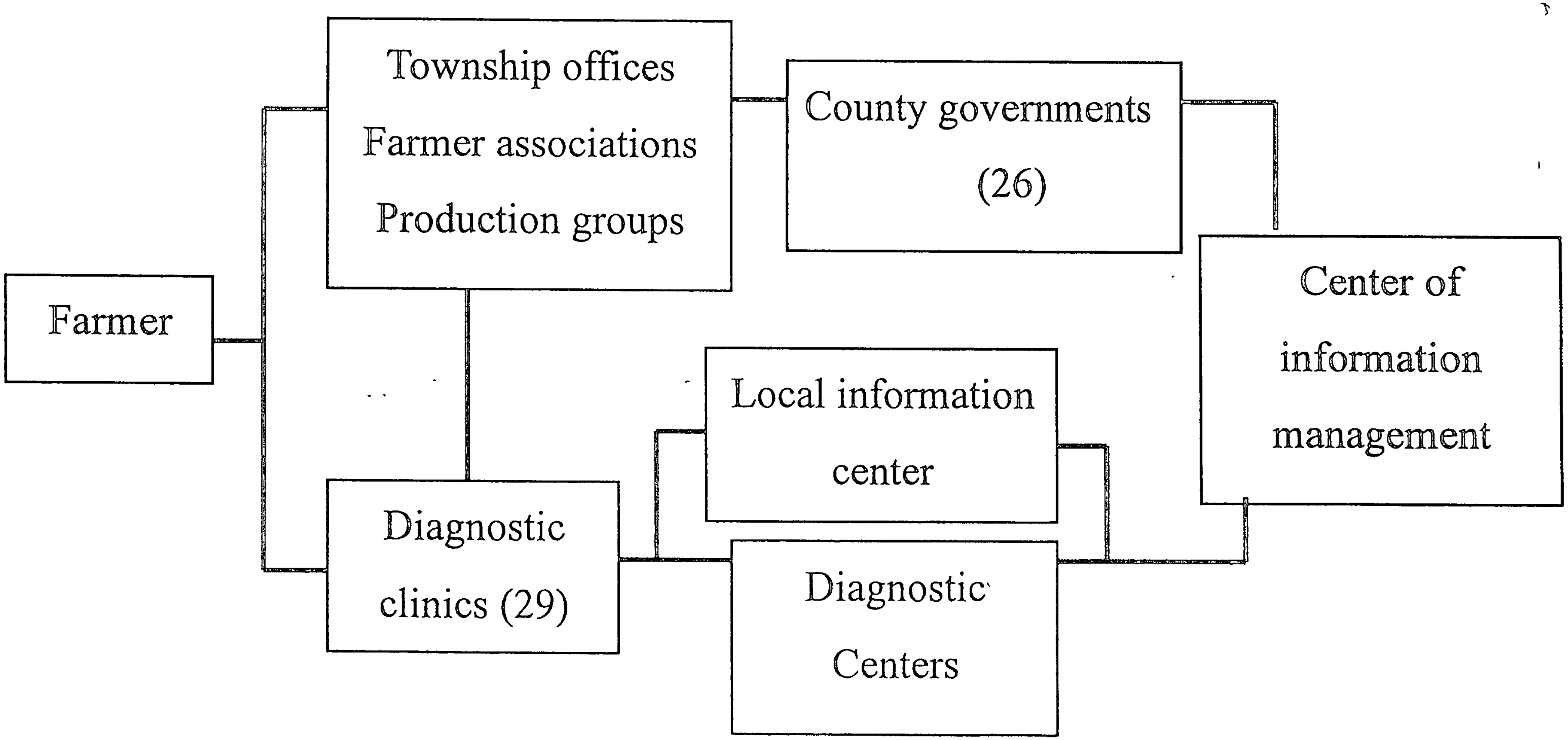
Center for pest identification: The center is located in the Taiwan Agriculture Research Institute (TARI). In addition, related universities such as National Taiwan University, National Chung Hsing University, National Chia-yi University and National Ping-tung University of Science and Technology are also in coordination with TARI in pest identification. About 40 taxonomic experts in entomology and plant pathology take part in the identification works, and their laboratories are all well equipped. The Center also assists diagnostic clinics in the identification of plant pests. Collection of specimens of plant pathogens and economic insects is located in TARI.

Diagnostic clinics: A diagnostic clinic was firstly established in Taiwan Agriculture Chemicals and Toxic Substances Research Institute in 1982. Since then, 29 clinics located in the DAIS and related research institutions were established subsequently. Each clinic has an extension plant pathologist or entomologist in charge of diseases and pest diagnosis and answering questions from growers as well as assisting or supervising in pest control. The clinical expert would send diagnostic report of each case through Internet to the center for information management (BAPHIQ) for further data analyses. Each year the clinics collectively received about three thousand diagnostic cases and have been proven very functional in uncovering newly invading pest species.

In regard to the monitoring system, a list of pests is designated under consistent nation-wide surveillance. The important monitoring systems are for the oriental fruit fly, melon fly, tobacco cutworm and beet army worm which are all under nation wide surveillance. Diagrams for population dynamics of each pest are posted on the TARI Web site every ten days, and alarms will be made if the population density is over the economic threshold. Besides, other thirty-three pests are also put under surveillance by local information centers to meet local interest.

The annual budget for operating the system is about US$ 3.26 million. As many as 150 scientists are involved. In order to make the system more efficient, the BAPHIQ is planning to recruit growers and pesticide wholesalers and retailers who have interest in joining in pest surveillance program, thus expanding the scope of the monitoring system.

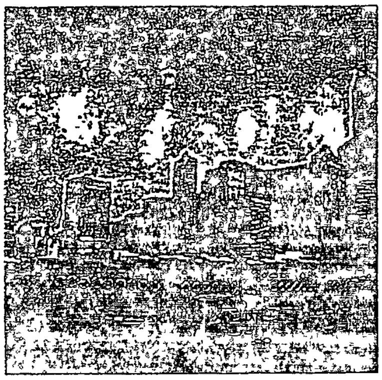
Figure 1. Diagram of diagnostic service in Taiwan

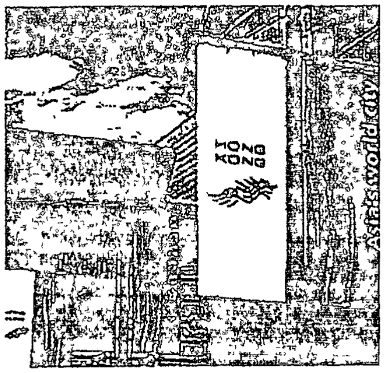


APEC Agricultural Technical Cooperation Working Group (ATCWG): APEC Workshop to Contain Transborder Movement Of Plant Pest: Diagnostics

(3-6 July 2001, Brisbane, Australia)

Country Report
Hong Kong Special Administrative Region
China (Hong Kong)





Tony Koon-wang WONG
Senior Field Officer
Agriculture, Fisheries and Conservation Department
Hong Kong SAR Government

Country Report: Hong Kong Special Administrative Region, China

Tony Koon-wang WONG
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HONG KONG

Introduction

Agriculture in Hong Kong is largely undertaken in urban fringes. Out of the territory's total land area of 1,097 square kilometers, only 27 square kilometers are currently farmed. About 5,300 farmers are engaged in production, representing 0.15 per cent of the total work force of the territory.

The local agricultural industry is directed towards the production of high quality fresh food through intensive land use and modern farming practices. The common crops cultivated are leafy vegetables, high value cut flowers and ornamental plants. Despite its relatively small size, the industry produces 48,000 tonnes of fresh vegetables providing for 11.7% of local consumption.

Organization of Plant Quarantine and Plant Protection Services

Plant quarantine and plant protection in Hong Kong are under the jurisdiction of the Agriculture, Fisheries and Conservation Department and are implemented by the Plant & Pesticides Regulatory Division and the Crops Division respectively.

Plant Quarantine Service

The Plant (Importation and Pest Control) Ordinance, Chapter 207 enacted in 1976 provides for the control of the importation of plants, plant pests and soil and for the prevention and spread of injurious pests in Hong Kong. Plant quarantine service is principally enforced by the Plant & Pesticides Regulatory Division. The Division is assisted by technical staff from the Import Control Section of our Department and disciplinary officers from the Customs and Excise Department at the entry points and waters of Hong Kong.

The law further empowers the Director of Agriculture, Fisheries and Conservation to inspect plants and plant products for the issue of phytosanitary certificates. In 2000, the department provided phytosanitary certification for 1,562 exporting plant consignments, which mainly included seeds, cuttings and raw medicine.

Quarantine Pests Established in Hong Kong
In recent years, natural populations of three quarantine insects have been found to have established in Hong Kong. They are the leucaena psyllid (*Heteropsylla cubana* Crawford), sago palm scale (*Aulacaspis yasumatsui* Takagi) and coconut leaf beetle (*Brontispa longissima* Gestro) attacking white popinac, sago palm and Palmae spp. respectively. They are well established and very wide spread in the territory. Eradication is impossible at this stage and scheduled intermittent spraying is the only means of temporary control.

Plant Protection Service – Local Pests
Over the past years, there were no serious pest and disease problems in plants. Commonly occurring pests include: fall armyworm (*Spodoptera litura*), vegetable leaf miner (*Liriomyza sativa* Blanchard), cabbage flea beetle (*Phyllotreta striolata*), diamondback moth (*Plutella xylostella*), cabbage whites (*Pieris spp.*), black cutworm (*Agrotis ipsilon*), oriental fruitfly (*Bactrocera dorsalis*) and melonfly (*Bactrocera cucubitae*).

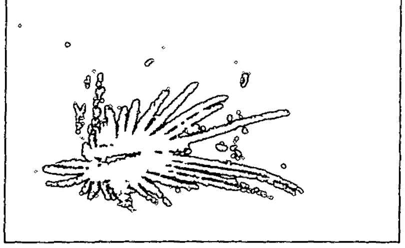
In comparison with damage caused by insects, crop losses caused by fungi, viruses and mycoplasma-like-organism (phytoplasma) are relatively less important as the cultivation of short term crop limits the development of disease epidemics. Nonetheless a few plant pathogens, such as the *Oidium* spp., *Sclerotinia sclerotiorum*, cucumber mosaic virus and turnip mosaic virus, can occasionally express serious pathogenicity and cause reduction in yield.

Integrated pest management systems using the nuclear polyhedrosis virus against the fall armyworm and cyromazine (an insect growth regulator) against leafminer were introduced to local vegetable farmers. We had also evaluated new technologies such as using petroleum spray oil to control fungal diseases and sucking insects, and using neem, a botanical insecticide, against a wide range of crop pests.

In addition, we had conducted local field surveys for Asian Longhorned Beetle and pinewood nematode. The results revealed that Asian Longhorned Beetle was not found in Hong Kong and the infection rate of pinewood nematodes in local pine trees was very low.

Through self-initiated and cooperative efforts, Hong Kong is maintaining a regular pest surveillance program.

Diagnostic Capabilities
Methods used:
(a) Bacterial identification
host pathogenicity tests, culturing and direct microscopy.



(b) Fungal identification
culturing, direct/microscope examination.

(c) Nematode identification
extraction from soil, extraction from plant tissue, direct/microscope examination.

(d) Insect pest identification
morphological taxanomy, direct/microscope examination, pest rearing procedure.

Uncertain specimens are referred to the CABI Bioscience UK and the South China Agricultural University for further identification.

Method of detection:
quarantine inspection, field search, farm visit, insect trap, light trap, pheromone trap, etc.

Means of data storage:
specimens keeping, insect museum, photographic records, hard copy files and computer data files.

Training
(i) Since last year, Departmental officers attended the following international plant protection seminar/workshop:-

Title of seminar/workshop	Date	City	Organization
Alternative Quarantine Treatment and Postharvest Handling Method	May 2000	Hawaii	APEC
Phytosanitary aspects of GMOs, Biosafety and Invasive Species	June 2000	Rome	FAO/ICPM

(ii) Two professors from the South China Agricultural University were invited in 2000 to conduct a one-week plant quarantine training course for our staff;

(iii) One entomologist from the Natural History Museum of London was invited in 1999 to conduct a one-week training course on whiteflies and general entomology for our staff.

COUNTRY REPORT OF INDONESIA

ON

THE CAPACITY TO DIAGNOSE PESTS AND MANAGE PLANT HEALTH DATA[1]

Sri Suharni Siwi (CRIFC) and Antarjo Dikin (CAQ)

1. Introduction

Correct identity of organisms used in biological investigation, surveillance and continuous monitoring of the status of pests and diseases is essential when formulating proper pest management programs In the context of international trade negotiations, specimens and other material contained in biological collections are the only acceptable records of pests that are known to exist within a country and so are vital components of quarantine policy and program

Indonesia is rich in natural resources, including numerous kinds of plants, fish and animals that need to be protected These basic natural resources constitute the basic wealth as well and are an important factor that ought to be taken into account in national development. The ever-increasing international and intra-national movement of plants, animals and fish through global trade, enhances the likelihood of the introduction of pests and diseases that may damage these natural resources Preventing such introductions requires a strong system of quarantine, a strengthening of the capacity to diagnose plant pests and diseases, and well managed plant health data.

, Indonesia there are many scattered sources of information and sscientists capable of P. F... ..agnostics that are situated within three different structures of organizations. (1) Ministry . Agriculture (MOA); (2) Indonesian Institute of Sciences (LIPI); and (3) Universities. In MOA, the scientists in plant pest and disease disciplines are located in different research institutions under the Agency for Agriculture Research and Development (AARD). Some officials in the Directorate of Crop Protection and Central of Agricultural Quarantine (CAQ) have capabilities to diagnose the common plant pests and diseases. This paper is written to give an overview of Indonesia's professional diagnostic capabilities and the need for a national identification service to enhance the ability of MOA to prevent /control trans-border movement of plant pests. These improvements will facilitate trade negotiations.

2. Ministry of Agriculture (MOA)

2.1. AARD. National Reference Insect Collection and Access to Diagnostic Technologies

Before 1980, all research institutes under MOA were contained within the Central Research Institute for Agriculture (CRIA), under the Directorate General of Agriculture. CRIA had several divisions, one of them was the Pest and Disease Division in which **a Scientific Insect Collection** is housed and well maintained providing excellent reference material. The collection began with an Old Dutch collection and acted as the national repository for plant pest records, dating back to the nineteenth century. Such a collection is essential for a country seeking to demonstrate knowledge of its plant health status, to predict the possible distribution of pests and to help with quick identification of pests and diseases materials. The collection contains species of economic importance to agriculture and forestry, quarantine pests and

[1] Paper presented on the APEC Workshop to contain Transborder Movement of Plant Pests: Diagnostic. The Bardon Centre, 390 Simpsons Road , Brisbane QLD, 3-6 July 2001.

beneficial parasites and predators Insects are preserved either dried or in alcohol During 1976 to 1979, the existing insect collection in the Plant Pest & Disease Division at CRIA was rehabilitated and research on insect taxonomy was strengthened with foreign technical assistance, i e. Dutch Government and Japan (JICA)

Since 1980, extensive restructuring in MOA has increased the organisation's size tremendously and also increased the offices and staff) The CRIA was divided into several research institutes based on commodities under the new authority of the AARD. The reference insect collection became part of the Central Research Institute for Food Crops (CRIFC). This institute is also divided into research institutions based on commodities such as rice, soybean, corn etc , and a lot of the expertise in disciplines relevant to pest (and host) identification is consequently spread out in different research institutes and in many different places. No organisation under AARD is devoted to offering a diagnostic service or maintenance of the existing reference collections. At present the estate crops research institute previously under MOA is located within the Ministry of Forestry A lot of voucher specimens of estate crop pests are maintained in the Reference Collection at CRIFC.

Research on Bio-systematics was a low priority in AARD. This resulted in inadequate research facilities and no funds being allocated to that field. As a consequence, researchers are not attracted to this discipline Limited skills in insect taxonomy and identification are the major constraints for the capability to detect, diagnose and respond to plant pest incursions

Poor national networking makes it difficult to list the national professional diagnostic skills available in the country. Access to diagnostic technologies to formulate proper pest management programs and to evaluate the quarantine risks associated with movement plant pests is also poor. A list of scattered scientists proficient in performing diagnostic and identification service is attached (see Questionnaire for Indonesia)

2.2. Centre for Agricultural Quarantine (CAQ)

Centre for Agricultural Quarantine (CAQ) is charged with preventing incursions of exotic plant pests and diseases into Indonesia and preventing the spread of quarantine pests between islands within Indonesia. Quarantine operations at entry points (seaport, post office, and airport) are legislated by the Quarantine Act 1992 concerning animal, fish and plant quarantine. Other regulations are applied to the importation of plants, namely MOA Decree no 38 of 1990 which regulates the importation of plant and plant propagating material imports into Indonesia.

Quarantine pests have been categorised into A1 (quarantine pests not yet present in Indonesia) and A2 (quarantine pests already present in Indonesia but with restricted distribution and under official control) At the moment, the A1 list contains around 600 species and the A2 pests consist of 65 species with limited distribution. A working group from universities, research institutes, plant protection organisations, and quarantine revises these lists every two years.

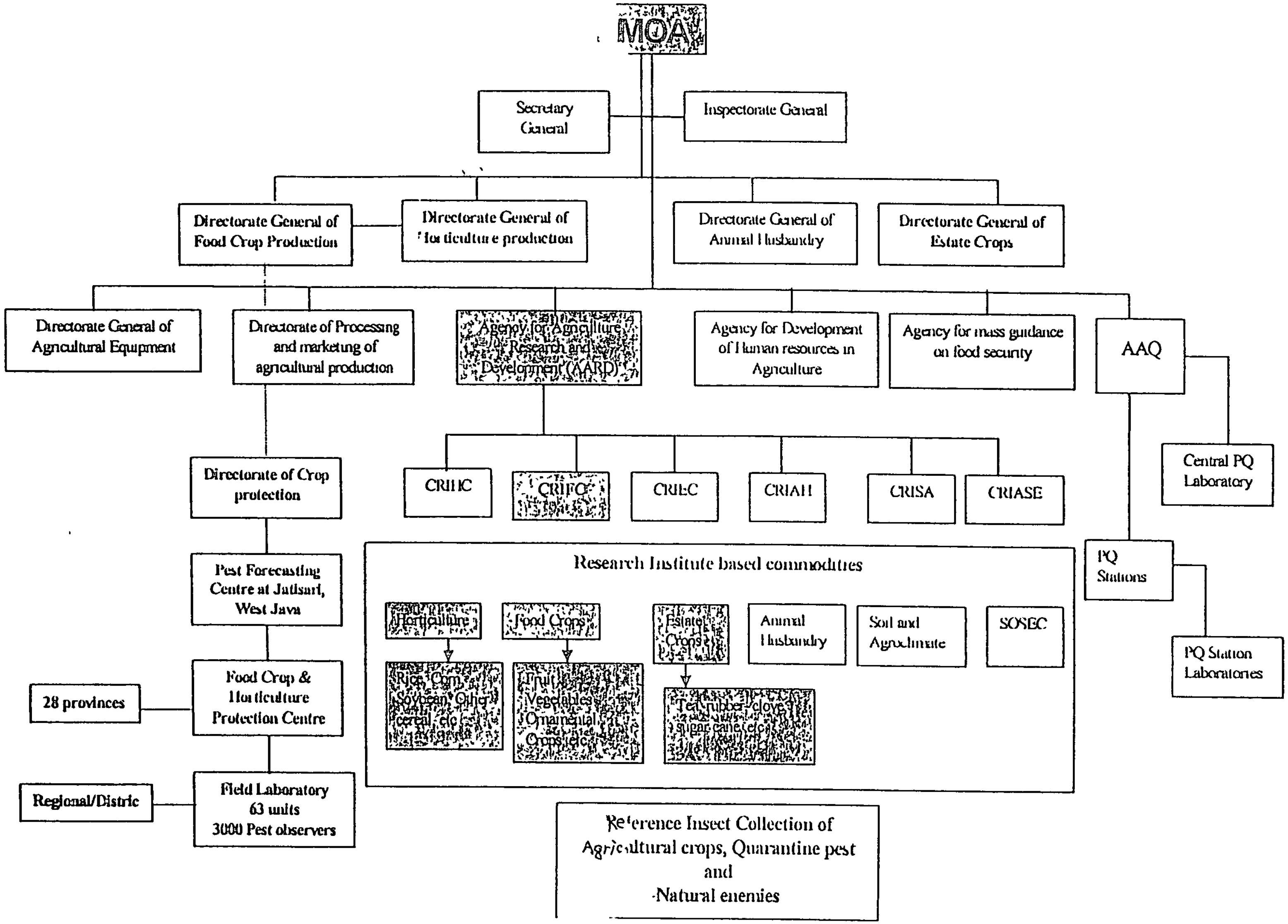
Plant Quarantine Laboratories have been set up in 5 plant quarantine stations that are located in Medan, Palembang, Jakarta, Surabaya and Makasar (Ujung Pandang). There are 78 plant quarantine stations throughout Indonesia. Each of these laboratories is able to identify insect pests and fungal diseases. These laboratories are supported with professional quarantine officers with backgrounds in entomology, mycology, bacteriology, virology, nematology and/or weed science.

The Centre for Plant Quarantine laboratory located in Jakarta acts as a reference laboratory and training centre for quarantine officers based at Plant Quarantine Stations. Other responsibilities of the Centre for Plant Quarantine laboratory are to arrange the implementation of quality assurance schemes.

The introduction of biological control agents has associated risks including the entry and establishment of quarantine pests associated with these agents. The operational procedures for

Attachment 1

PRESENT STRUCTURE OF THE MOA



APEC WORKSHOP TO CONTAIN TRANSBORDER MOVEMENT OF PLANT PESTS: DIAGNOSTICS

3 – 6 JULY 2001
BRISBANE, AUSTRALIA

COUNTRY REPORT
MALAYSIA

CROP PROTECTION & PLANT QUARANTINE DIVISION
DEPARTMENT OF AGRICULTURE
MALAYSIA

JULY 2001

APEC WORKSHOP TO CONTAIN TRANSBORDER MOVEMENT OF PLANT PESTS: DIAGNOSTICS

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COUNTRY REPORT - MALAYSIA

1. Introduction

Malaysia is located in the tropics with a total land area of 330,000 square kilometers and is essentially a plantation crop-oriented agriculture country. The major crops are oil palm, rubber cocoa, pepper and coconut. Rice is our food crop. At present, oil palm, rubber and timber sectors are the major part of the country's export and contribute significantly to foreign exchange earnings. Other crops like fruits, vegetable and tobacco also contribute in exports earning in a small scale. Recent increase in the number of agricultural consignments of 320,761 and 340,284, with estimated value of RM4.86 billion and RM4.81 billion in 1999 and 2000 respectively (imported through the plant quarantine entry points), made it difficult for the present plant quarantine system to safeguard from the entry of dangerous foreign pests. New challenges include increases in tourism, air traffic and the growing demand for new germplasm and plant varieties for crop improvement. It is crucial now to upgrade the existing capabilities of plant quarantine system especially in the diagnostic area to prevent the introduction of exotic pests into the country.

2. Organizational Structure

The Department of Agriculture (DOA) under the Ministry of Agriculture is responsible for the implementation of the plant protection activity, Plant Quarantine Act 1976, and Plant Quarantine Regulations 1981.The main objectives of the Act and Regulations are to prevent the entry and establishment of plant diseases and pests into the country and at the same time to facilitate the movement of plants and plant products in the international trade.

The Crop Protection and Plant Quarantine Services Division (CP&PQSD) of the DOA is the headquarter for all the plant quarantine and crop protection activities and serves as the referral point for decisions on all crop protection matters and the enforcement of the Plant Quarantine Act 1976 and the Regulations 1981. The Peninsular Malaysia is comprised of 13 states and each state has a Unit of CP&PQSD where some of the quarantine and diagnostic services are carried out. There are a total of 49 entry points in the country where agricultural materials can be imported. Among them are airports (10), sea ports (10), and the rest are land entry points (29) either by road or railway.

The DOA Malaysia recognized that diagnostic screening is crucial to ascertain that all importation consignments are free from dangerous pest that can pose a threat to our economic crops. Under the Eighth Malaysia Plan, proposals are made to establish four regional diagnostic laboratories stationed at State of Kedah, Johor, Kelantan and Pahang in Peninsular Malaysia. The main diagnostic activity of pests and diseases at the DOA is based at the headquarters of CP&PQSD office. Currently there are 19 staff at the headquarters office working in the various sections of the diagnostic services that includes pathology, entomology, nematology and weed section. The office of CP&PQSD of DOA, have two officers who are familiar with identifying the Order of certain Hemiptera, Lepidoptera and Diptera. However, there is no expertise in other areas such as bacteriology, mycology, nematology, and virology.

At present the Pathology and Post Entry Quarantine Section of the CP&PQSD were equipped with the PCR (Polymerase Chain Reaction) facilities, BIOLOG system and ELISA diagnostic laboratories. Recently DOA has carried out some screening work using PCR, BIOLOG system, and ELISA techniques on certain specific plant viruses, bacteria, fungi and phytoplasma organism as shown in ANNEX 1.

In addition, to reinforce our analytical capacities we seek cooperation with research organizations, institutes of higher learning and local public agencies to verify our results using molecular techniques as well as electronic microscopy. DO[illegible] subscribes to an integrated approach by seeking oversea research organizations and Institutes of higher learning to assist in diagnostic problems. Pest or disease which cannot be identified or is unknown to us, will be sent for identification to one of the overseas international organizations such as the London British Museum, Commonwealth Institute of Entomology, CAB International, or the International Institute of Mycology in United Kingdom. DOA usually seeks diagnostic services from the local research organizations and institutes of higher learning on personal-to-personal basis. There is no formal networking or collaboration between various local or overseas institutions or research organizations with DOA in the area of diagnostic services.

Most of the Institutes of higher learning and the commercial agencies will charge a fee for providing a diagnostic service. However, at present diagnostic services provided by the public agencies, research institutes and organizations for DOA are free.

3. Diagnostic Service Agencies/Organizations

Some of the diagnostic service agencies or organizations that are available in Malaysia are as follows:

I) Institutes of Higher Learning
- includes University of Malaya (MU), University Putra Malaysia (UPM), National University of Malaysia and University Sciences Malaysia (USM).

II) Research organization
- Malaysian Agricultural Research and Development Institute (MARDI)
- Malaysian Palm Oil Board (MPOB)
- Forest Research Institute of Malaysia (FRIM)
- Malaysian Rubber Board (MRB)

III) Public agencies
- Department of Veterinary
- Department of Fisheries
- Institute of Medical Research

IV) Commercial agencies
- Technicvest Limit
- Bio-Diagnostic Limited

4. National Professional Diagnostic Skills

The diagnostic services available in the research organizations and institutes of higher learning in Malaysia that have the professional staff are able to conduct diagnostic tests to identify certain pests and diseases as shown in Annex 2.

5. Reference Collection

In term, of pest and disease reference collections, DOA has some reasonable good collections for the Orders of Coleopteran, Diptera, Hymenoptera and Lepidoptera. However, with regards to a pathogen and nematode reference collection there is a need to seek assistance and collaboration work in this area. To date, more than 2,000 Fusarium isolates associated with agriculture products in Malaysia have been isolated, identified and preserved at the Fusarium Culture Collection Laboratory, University Science Malaysia. The establishment of the collection can assist the diagnostic personnel or the plant quarantine inspectors in differentiating pests and diseases that are prohibited, restricted or noxious from the pests and diseases that are found locally.

6. Constraints Encountered In The Diagnosis Of Pests And Diseases

Some of the present major constraints that DOA faces in the field of pests and diseases diagnostics are highlighted as follows:

1. In general, there is lack of skills and ability of personnel in DOA to identify accurately the insects of certain Orders, pathogens and nematodes to the species and strains level. Most of the personnel are only specialized in a particular area. It is of paramount importance to develop human resources in this field.

2. Lack of reliable test protocols using molecular techniques for the rapid and accurate detection of exotic pests, diseases and also transgenic crops is of concern to Malaysia. It is important that some form of collaborative work and assistance be designed to, develop and conduct the specific test protocols for the detection of the following exotic pests, diseases and transgenic crops :

a) Insects

- I) Fruitflies – *Bactrocera latifron, B. tryoni, Ceratittis capitata*
- II) Whitefly – *Aleurodicus coccis*
- III) Leafminers - *Chromatomyia horticola, Liriomyza huidobrensis*
- IV) Thrips – *Thrips palmi*

b) Diseases:

- I) Fusarium wilt of palm (*Fusarium oxysporum* f. sp *elaeidis)*
- II) *Xanthomonas ciitri* (with 3 strains)
- III) South American Leaf Blight [SALB] *(Microcyclus ulei)*
- IV) Cocoa Swollen Shoot virus

c) Transgenic crops

3. Imperfect access to right material (e.g. getting the original sample) and unavailability of primers and antisera for screening diseases such as Cocoa Swollen Shoot Virus (CSSV), MLO for sugarcane and other exotic diseases.

4. Training of personnel is crucial in order to be abreast with the latest developments in the field of PCR technology for diagnosis of the diseases of concern. Trained personnel need to be technically competent in ascertaining the phytosanitary requirements for the importation and exportation of agricultural commodities.

5. Inadequate funding in terms of providing;

    i) training in specialized fields for detection of exotic pests and diseases.
    ii) diagnostic equipments and facilities for detection of nematode and exotic pathogens.

6. Lack of reference collection of certain invasive/exotic insects, pathogens and nematodes of plant quarantine concern to Malaysia such as the fruitflies, whiteflies, leafminers, thrips, mites, *Xanthomonas* sp. and *Ganoderma* sp.

7. No formal networking or collaboration programme in terms of access to:

    i) International or local institutes or organizations on diagnostic services.
    ii) Information on testing protocols and techniques for rapid diagnosis on quarantine plant pests and diseases.

7. Conclusions

The diagnostic function need to be improved on capabilities and techniques through a human resource development programme with the assistance from local, regional or international collaborating agencies. The ability to diagnose accurately and rapidly pests and diseases is necessary in helping to make correct decisions for formulating quick action. In addition, it will help to refrain from legal complications in preventing introduction of exotic pests and diseases into the country and at the same time to help in facilitation of trade.

ANNEX 1

List Of Viruses/Viroids Screening Test Using ELISA & PCR Techniques

1. Banana Bunchy Top Virus (BBTV)
2. Cymbidium Mosaic Virus (CyMV)
3. Cymbodium Ringspot Virus (CRSV)
4. Odontoglossum Ringspot Virus (ORSV)
5. Maize Dwarf Mosaic Virus (MDMV)
6. Papaya Ringspot Virus (PRSV)
7. Tomato Ringspot Virus (ToRSV)
8. Tomato Spotted Wilt Virus (TSWV)
9. Lilium Symptomless Virus (LSV)
10. Tobacco Ringspot Virus (TRSV)
11. Tobacco Rattle Virus (TRV)
12. Potyvirus Group (POTY)
13. Cucumber Mosaic Virus (CMV)
14. Strawberry Latent Ringspot Virus (SLRSV)

List Of Bacteria Screening Using BIOLOG System Technique

1. Banana - *Ralstonia solanacerum* (Moko Disease)
2. Coffee - *Pseudomonas garcea* (Bacterial leaf spot)
3. Maize - *Erwinia stewartii* (Bacterial wilt)
4. Sugarcane - *Xanthomonas albilinean* (Leaf Scald)

   - *Xanthomonas campestris p.v vasculorum* (Gumming disease)

ANNEX 2

List Of National Diagnostic Skills

A. From Institutes of Higher Learning:

1. University Putra Malaysia (UPM)

Name	Area of Expertise	Laboratory
Dr. Kamaruzaman Sijam	Bacteria	Culture/PCR
Dr. Tan Yee How	Bacteria	Culture/PCR
Dr. Zainal Abidin Ahmad	Fungus	Culture
Prof. Sariah Moen	Duetromycetes Fungi	Culture & PCR
Dr. Inon Sulaiman	Virus	PCR
Prof. Noraini Samad	Virus	PCR
Dr. Rita Mohamad	Family :Myridae	Biochemical taxonomy
Ms. Normah Osman	Stored Product Pest	*
Dr. Rohani Ibrahim	Diptera	*
Dr. Yusof Ibrahim	Mites	*
Prof. Abdul Rahman Razak	Nematode	EM

2. University of Malaya (MU)

Name	Area of Expertise	Laboratory
Dr. Rosina Yasmin	Virus	PCR/ELISA
Dr. Vikaineswary Sabaratnam	Fungus	Culture
Dr. Koh Chong Lek	Bacteria	Culture/PCR

3. National University of Malaysia (NUM)

Name	Area of Expertise	Laboratory
Prof. Mohd Salleh Mohd Said	Hymenoptera/ Coleoptera	*
Dr. Zaidi Mat ISa	Lepidoptera/ Homoptera	*
Dr. Abdul Idris Ghani	Braconid	*
Prof. Ahmad Ismail	Virus	PCR

4. University Sciences Malaysia (USM).

Name	Area of Expertise	Laboratory
Prof. Baharuddin Salleh	Fusarium	RPD
Dr. Liew Kon Wei	Fusarium	Culture

B. From Research Organization

1. Malaysian Agricultural Research Development Institute (MARDI)

Name	Area of Expertise	Laboratory
Dr. Lum Keng Yeang	Bacteria	PCR/ELISA
Dr. Suhaimi Masduki	Bacteria (Environ.)	PCR
Dr. Ong Chin Ang	Virus	PCR
Dr Nik Masdek Nik Hassan	Fungus	*
Dr Karim Sidam	Nematode	
Mr. Yuen Pak Mun	Nematode	
Dr. Vijasageran	Fruit fly	*
Mohamad Mohd. Salleh	Lepidoptera (fruits)	*
Jamaluddin Salim	Lepidoptera (Veg.)	*

2. Malaysian Palm Oil Board (MPOB)

Name	Area of Expertise	Laboratory
Dr. Norman Hj. Kamarudin	Parasitic Hymenoptera assoc. with bagworms & nettle caterpillars	*
Dr. Siti Ramlah Ahmad Ali	Enterobacteriaceae & Bacillaceae assoc. with bagworms & rhinoceros beetles	*
Dr. Idris Abu Seman	Basidiomycetes assoc. with oil plam & coconut	*

3. Forest Research Institute of Malaysia (FRIM)

Name	Area of Expertise	Laboratory
Dr. Laurence G. Kirton	Forest insects	*
Dr. Andrew H. H. Wong	Soft rot fungus on wood	Culture
Dr. Salmiah Ujang	Wood decay fungus	Culture

4. Malaysian Rubber Board (MRB)

Name	Area of Expertise	Laboratory
Mr. Shamsuri Mohd Hidir	Fungus	Culture

Note: * with laboratory infrastructure and equipments to carry out identification of insects.

Diagnostic Practices for Containing Transborder Movement of Plant Pests in China

Introduction

China is a major agriculture country with a large population and limited arable land. Agriculture is the foundation industry of the national economy. Ensuring the safety in production of agriculture and forestry is the prime target of the government's agriculture policy. Preventing the spread of harmful diseases, insect pests and weeds is an important aspect of ensuring the safety of agricultural systems. Due to the great diversity in climate, ecology and cultivation style in China, serious risks of exotic pests invading from border or spreading out from special areas are unavoidable. In order to reduce those risks effectively, the related agencies, laws and regulations, technologies, training programs and projects have been developed.

Related agencies

The national agencies for containing harmful plant pests in China include the Department of Crop Production of Ministry of Agriculture (MOA) and the National Agro-Technical Extension and Service Centre (NATESC), which is attached directly to MOA. In accordance with Regulations of the P.R. China on Plant Quarantine and the State Council decision, MOA is in charge of national plant quarantine. It's responsibilities are as follow:

1. In charge of national plant quarantine;
2. Draft laws and Regulations on plant quarantine;
3. Sign the agreement between or among governments;
4. Formulate relevant standards;
5. Organize domestic plant quarantine;
6. Issue epidemic situation;
7. Organize relevant agencies to eradicate quarantine pests.

Under these agencies, a well-organized network of Phytosanitary units of different administrative levels was established to carry out the state plant quarantine tasks.

Related laws and regulations

Laws of the PRC on entry and exit in relation to Animal and Plant Quarantine, and Regulations of the PRC on Plant Quarantine, are the basic rules which were formulated for the purpose of preventing the spread of harmful diseases, insects and weeds dangerous to plants. According to these laws and regulations, plants and plant products that may be carrying dangerous pests must be identified before they are transferred out from a production area. For all seeds, seedlings and propagating materials, Quarantine inspection must been performed to ensure that they are free from plant quarantine objects.

Related technologies

In recent years, the research and application on plant quarantine standards have being undertaken robustly. Up to now, about 10 national technologies rule standards on plant quarantine have been issued, which include seeds or seedlings of wheat, rice, cotton, soybean, potato, sweet potato, apple, citrus and transporting of agriculture plants. A series of pest-free seed and seedling propagation bases have been established by carrying out the above standards. By implementing these technologies rule standards, the expertise of staff for diagnosing and containing dangerous plant pests has been improved.

Training programs and projects

In March 1987, the National Plant Quarantine Training Center was established in Zhejiang Agriculture University by MOA, which assumed the role of training for national plant quarantine inspectors. More than 1000 staff have been trained by this center. NATESC has been carrying out a 3-year national quarantine staff training project. The training course includes: international and domestic quarantine regulations; quarantine techniques; and information technology. Through implementing those training programs and projects, the systematic knowledge of the staff for diagnosing harmful plant pests has greatly improved.

Development status of pest risk analysis (PRA)

China's quarantine institutions attach great importance to the PRA work. Early in the 1980s, China began to carry out comprehensive evaluation and research on the adaptability of the harmful organisms coming from the outside world. Since the 1990s, China has set up a specific risk analysis research program to explore the methods and procedures for risk analysis on harmful organism. Researchers had carried out some analysis of the important harmful organisms, this lay down a profound theoretical basis for the development of PRA in China. More than 20 PRA reports on foreign agro-products entering into China have been completed. Those reports played an important role in negotiations for allowance of market entry as well as animal and plant quarantine between China and USA, China and Australia, and China and EU. At present all new plants and plant products entering into China are to be analyzed by the method of PRA. PRA is a very important procedure which cannot be deleted in policy making.

Related capacities and needs

Generally speaking, China already has a good trained quarantine staff and roughly equipped quarantine facilities. This allows us to monitor and diagnose the harmful plant diseases and pests effectively. In recent years, plant quarantine organisations and staff at various levels have actively studied and applied plant quarantine science and technologies to block and eradicate dangerous exotic plant diseases and pests. We have now wiped out *Radopholus similis* (Cobb)Thorne, and contained *Lissorhoptrus oryzophilus Kuschel* and *Liriomyza* spp. within patch areas.

China ,is aspiring to become a member of the WTO. We need to have an extensive understanding of the international laws, regulations, rules and agreements about plant health and protection. As plant health has become a major trade issue for WTO, we want to have more experience of how to deal with the related issues for reference. Meanwhile, the advanced diagnosing facilities is insufficient in China. We would like to enhance the cooperation in the following aspects:

1. Information collection and exchange:

As a matter of fact, many dangerous pests (quarantine-relevant organisms) have never been existent in some countries. Inspecting and diagnosing those pests will mainly be based on the information of their morphology, habits, host ranges, geographical distribution and molecular characteristics. This information is essential when developing supporting measures to enhance the capacity of diagnostics.

2. Staff training items:

The main purposes of staff training items is to allow participants to effectively share their rights and undertake their obligations under the SPS agreement and other related international plant health conventions.

3. Related resources sharing mechanism

Plant diagnostic activities in Korea: Country report for APEC workshop

Choi, June-Yeol and Lee, Young Kee
NIAST, RDA, Korea

Korea (South) is a country of rugged, mountainous terrain with more than 46 million people on 98,445 square km. The amount of transborder movement of agricultural products in Korea has to be much larger by its high population and small area. Because of its geographic condition, all the trade has to be done by ship or plane. The larger the volume of trade becomes, the greater the opportunity of foreign pests influx. According to the report of NPQS, 229,907 cases were investigated in 2000, though only 44,043 cases in 1990. The rate of newly inflowed pests detection gets faster. After 1990, several pests were detected for the first time, and they caused big problems. U.S.A. and Japan were the most important counterparts in the trade in the past. Recently, import from China grows larger. The concerns about transborder movement, diagnostics, and management of plant pests increase gradually. Especially, national diagnostic surveys of pests is the most important activity for protecting Korean agriculture.

There are two national diagnostic services in Korea; Rural Development Administration (RDA) and National Plant Quarantine Service (NPQS). RDA treats the domestic matters, and NPQS does international ones.

The functions of RDA are as follows: Research and development of agricultural technologies, Dissemination of agricultural technologies and information, Production and distribution of crop seeds Quality control of fertilizers, pesticides and agro-machineries, and Diffusion of rural development and home improvement technologies. To achieve these goals, RDA [illegible] [illegible] and [illegible]tations around the country, and an Agricultural Research and Extension Serveces (ARES) in each province. There is an Agricultural Development and Technology Center (ADTEC) in almost every county. All the ADTECs are under the guidance of ARES.

National Institute of Agricultural Science and Technology (NIAST) is one of them, and research mainly on the basic factors of agriculture, including major plant diagnostic services in the RDA. Some of institutes or stations in the RDA also have a diagnostic function, but their main goals are related to cultural method, and so on. NIAST is composed of four departments. Division of plant pathology and division of entomology are under department of crop protection. Though researchers of weed science constitute a special team, they are in the division of plant pathology in the organization.

There are six laboratories in the division of entomology; Insect taxonomy, Insect ecology, Insect physiology, Natural enemy, IPM, and Nematology. There are six laboratories in the division of plant pathology; Taxonomy and diagnosis, Physiology and genetics, Ecology and management, Biological control, Virus, and Weed science.

The NPQS functions are as follow: Quarantine inspection of importing and exporting plant products, Cooperation with other countries on quarantine issues, Research and investigation on exotic plant pests, and Development of treatment method for plant products. The NPQS is composed of six divisions in headquarter, five branch offices, two post-entry quarantine stations, and 18 regional offices. Three divisions in the headquarter, the treatment management division, the pathogen research division and the insect research division, have a charge to carry out practical matters in research field.

As yet, there are no commercial agencies in Korea. Therefore, the survey on the pests and diseases is the unique duty of the government. Recently, some researchers wanted to settle that kinds of commercial agencies, but practical activities have not yet been shown. It is expected that these kind of trials will start in the near future.

Central and provincial governments cooperate on the crop protection program. RDA is the center of the program, with the pest-forecasting system being operated around the country. This system comprises periodical forecasting on the basic plots and observation plots, and informal forecasting by pest specialists. RDA, provincial ARES, and Agricultural Development and Technology Center (ADTEC) manage periodical forecasting. RDA has made and distributed a standard in each forecasting.

There are 150 fields in nationwide rice pest forecasting system, and nine diseases and twelve insects are counted every 10 days. Spore collector, light trap, insect net, arthropods trap, and yellow pan trap are used additionally in summer. The results taken from each trap are sent to RDA daily. The budgets for forecasting are supported by central and provincial governments. The other 50 fields are investigated every 15 days for pest forecasting of cash crops, like red pepper, garlic, Chinese cabbage, sesame, peanut, and so on. Each crop is changed by the region. Their targets are composed of 22 disease and 12 insects. Spore collector, blue-light trap, yellow pan trap, funnel trap, and pheromone trap are used for cash crop, and the management method is the same as for rice.

Direct survey in the field is the very first step in plant pests diagnosis. Identification methods are chosen in accordance with specific pests; culture, host pathogenicity, microscopy (LM, TEM/SEM), ELISA, physiological and biochemical test, molecular tests (PCR) *etc.* for pathogen, extraction from soil, extraction from plant tissue, direct/microscope examination, northern blots, PCR, *etc.* for nematode, and morphological taxonomy, direct/microscope examination, pest rearing procedure, *etc.* for insect pests identification. PCR for insects is done in a different department of NIAST, and digital methods need to be adopted. Microscope examination of stored specimens in the collection is used for identifying insect pests, too.

Major constraints on diagnosis of plant pests are insufficient expertise and the preparatory information on the pests from abroad. For example, lack of Korean specialists on Agromyzidae and poor references including *Liriomyza trifolii* is a big problem. Thrips are a similar case. Therefore, a more reliable or rapid test should be developed on *Liriomyza trifolii* and other agromyzid species, and *Frankliniella occidentalis, Thrips palmi,* and other thrips.

Korean diagnostic services mainly invite foreign specialists to RDA or NPQS to cooperate on the specific pests, annually. Except, there is no special connection with other diagnostic providers from abroad. Therefore, Korean diagnostic services are trying to make formal linkages with other services abroad.

For many years, through these surveys, RDA and NPQS comprised various reference collections. For insect pests, RDA (NIAST) has managed an insect specimen room after 1960's. It stores about 330,000 specimens. NPQS stores about 50,000 specimens, including those detected in quarantine service. Pathogens isolated from diagnostic samples are maintained in limited rooms in RDA by subculturing, freezing, freeze-drying, and other methods. NPQS maintains samples the same way, except freeze-drying. Text data are mainly stored as computer files. They would like to make a database for better use.

Though many pests have been recorded so far, most of the damages come from some major pests. The 10 major diseases of Korea are: *Magnaporthe grisea (Pyricularia grisea), Thanatephrus cucumeris (Rhizoctonia solani); Fusarium oxysporum; Glomerella cingulata (Colletotrichum gloeosporioides); Pseudopernospora cubensis; Sphaerotheca fuliginea; Phytophthora capsici; Ralstonia solanacearum;* Potato leaf roll virus; and Tobacco mosaic virus. The 10 major insect pests of Korea are: *Nilaparvata lugens; Lissorhoptrus oryzophilus; Spodoptera exigua, Spodoptera litura; Tetranychus urticae, Frankliniella occidentalis; Thrips palmi, Liriomyza trifolii; Thecodiplosis japonensis;* and *Myzus persicae.*

Usually, government does not compensate for all the losses caused by pests. It, however, supports the expenses for control in the special cases. Especially, for problems related to foreign pests, the government has a charge to eliminate them. The effectiveness of pest control can be expressed in two ways; amount and money. There was an increase of 732,320 ton and 1 billion USD in the rice production by the control in 2000.

"The list of Korean plant disease, insect pest, and weed" was published by the Korean society of plant protection in 1986 There are 1,539 diseases, 2,618 pests of insects, nematodes, mites etc., and 461 weeds in the list. In 1998, the Korean society of plant pathology also compiled a list, which contained 2,771 diseases from 879 plant species, based on the former records. However, the occurrence of only 1,298 diseases from 165 plant species was confirmed.

[illegible]d two lists of foreign pests. One deals with pests already invaded, [illegible] lists foreign pests which may cause problems in the domestic crop cultivation, if they flow in. There are 21 diseases and 33 insect pests in the former. They divide pests into three categories in the latter: Regulated pest, Provisional regulated pest, and Non-quarantine pest. Regulated pest is divided again into quarantine pest, which is composed of 44 prohibited pests and 1,295 controlled pest, and regulated non-quarantine pest.

RDA and NPQS are always trying to share their information about the current problems on the agriculture, and to cooperate to solve the problem. Sometimes they ask other institutions or universities for specialist assistance with taxon identification and diagnostic techniques.

From 1996 to 2000, RDA carried out a nationwide survey of plant pests and pathogens to determine the real plant health status. NPQS also participated in the project. A total of 65 crops, composed of fruit trees, vegetables, flowers, food crops (rice, bean *etc.*), medicinal herbs, mushrooms, and wild vegetables, were surveyed in the project. The analysis of the results is being prepared. The list of Korean plant diseases, insect pests, and weeds, which was published in 1986, will be altered by the results. Additionally, RDA has a plan for a better forecasting system, as a succeeding project of the former for the following five years. A new forecasting system for major notorious pests and diseases will be settled.

International cooperation in forecasting, detecting, monitoring, and controlling pests is not an easy way to go, but it is the best way for the sake of a better agriculture with less pest problems.

Plant Quarantine Diagnosis in Thailand [1]
by
Komsan Jumroonpong [2]

Plant quarantine regulations are generally intended to preclude or restrict the movement of plant pests into new area by regulating the movement of plant materials. Most plant pests are disseminated long distances and into new area primarily by mean infected, infested or contaminated plant materials. The effectiveness of plant quarantine services as well as other plant pest management strategies depends on rapid and accurate pest inspection, diagnostic and identification of plant pests. Furthermore, as a result of increasing movement of plants, plant parts and plant propagative materials including soil, the plant quarantine diagnosis is the most important. There is a need of effective, reliable, accurate, and rapid methods for detection and identification of plant pests.

Plant Protection Organization

The Department of Agriculture (DOA) is headed by Director-General and three Deputy Director-General. Operation is conducted through twelve divisions, five research institutes and eight agricultural research and development offices. Three divisions namely, Plant Pathology and Microbiology Division, Entomology and Zoology Division and Agricultural Regulatory Division are responsible for the plant protection section of DOA, and technical collaboration in research and development with academic institutes such as Kasetsart University, Khon Khan University, Chiang Mai University.

Currently, Thailand Plant Quarantine Service is a part of Agricultural Regulatory Division, Department of Agriculture, Ministry of Agriculture and Cooperatives. The plant quarantine service has been divided into two units called the Plant Quarantine Station and the Plant Quarantine Sub-Division.

Activities of Thailand Plant Quarantine Service are categorized under each of the following unit:

Plant Quarantine Station

- Enforcing Plant Quarantine Act B.E. 2507 (1964) amended Plant Quarantine Act (2nd Edition) B.E. 2542 (1999) and all regulations pertaining to the Act.
- Inspection consignments of plants import through 31 PQ. Stations.
- Conducting treatment/or refusing entry of plants into the Kingdom of Thailand.
- Issuing Import permits and Phytosanitary certificate for importation and exportation of plant materials.
- Cooperating with international bodies on plant protection.

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[1] Paper presented at the APEC Workshop to Contain Transborder Movement of Plant Pests: Diagnostics, The Bardon Centre, Brisbane, Australia. 3-6 July, 2001

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Plant Quarantine Sub-Division

- Conducting routine inspection, diagnosis, and identification of diseases and pests on imported materials.
- Conducting researches with particular emphasis on the development of quick and reliable techniques for detection of diseases and pests and effective treatment procedures.
- Conducting post-entry quarantine processing on imported materials of some crops.
- Conducting field inspection and monitoring of imported materials.
- Providing all technical information to all plant quarantine stations.
- Compilation of information regarding diseases and pests not known to occur in Thailand.
- Conducting in-service training and also conducting special courses for other related government agencies and education institutes.

Thailand Plant Quarantine Services

Plant Quarantine Sub-Division is the legal office for diagnostic of diseases and pests, consisted of three technical sections and the post-entry quarantine station as follows:

1. Plant Quarantine Pathology Section, It consists three laboratories namely Mycology, Bacteriology and Virology Laboratory.
2. Plant Quarantine Pests Section, It consists three laboratories namely Entomology, Acarology, Nematology and Botanical and Weed Laboratory.
3. Plant Quarantine Standard and Export Services.

Diagnostic of Plant Diseases and Pests

a. Virus/Viroid identification, method used:

1 Indicator plants
2 Microscopy - EM/SEM
3 ELISA
4 Dot blots

- test for specific viruses/viroids.
  - Tomato spotted wilt virus
  - Tomato bushy stunt virus
  - Squash mosaic virus
  - Cymbidium mosaic virus
  - Potato virus Y

b. Bacterial identification, method used:

1 Host pathogenicity tests
2 Culturing
3 Direct microscopy
4 ELISA
5 Biochemical (species ID)

- test for specific pathogenic bacteria.

- *Erwinia stewartii*
- *Erwinia carotovora*
- *Erwinia chrysanthemi*
- *Pseudomonas solanacearum*
- *Pseudomonas syringae*
- *Pseudomonas corrugata*
- *Acidororax avenae pv. citrullic*
- *Xanthomonas campestris* pv. *vesicatoria*
- *Corynebacterium michiganense*

c. **Fungal identification**, methods used:

1. Culturing
2. Direct/Microscope examination
3. Bioassays

- test for specific fungi.
  - Pathogenicity test on specific hosts
  - *Fusarium oxysporum* f.sp. *lycopersici* :tomato
  - *Fusarium oxysporum* f.sp. *melonis* : melon

d. **Phytoplasma identification,** methods used:

1. Pathogenicity/indexing
2. Direct/Microscope examination (Ultra-thin section and Electronmicroscopy)

- test for specific phytoplasma
  - Tomato Big Bud [illegible] nd grafting on indexing plant

e. **Nematode identification,** methods used:

1. Extraction from soil
2. Extraction from plant tissue
3. Direct/Microscope examination

- test for specific.
  - Golden Cyst Nematode by Heavy Sugar Centrifugation

f. **Insect pest identification,** method used:

1. Morphological taxonomy
   1.1 Digital methods, CD-based keys by LUCID
   1.2 Direct/Microscope examination
   1.3 Pest rearing procedure

Plant Quarantine Pest List

The Plant Quarantine Act B.E. 2507 (1964) amended by Plant Quarantine Act (2nd Edition) B.E. 2542 (1999) is the legal basis for issuing Ministerial Regulations and Notifications restricting certain things, to reduce the chance of pests introduction or spread within Thailand. Under section 6 of this Act, the Minister of MOAC has notified in the Government Gazette the names of eighty two species that are prohibited to enter the Kingdom. The names of eighty two prohibited materials are the list of disease-causing agents and pests of national significance as shown in **Annex 1**.

In accordance with this Act, the plant or plant materials including other plant quarantine objects being imported into the country, had been arranged into three categories:

1. Prohibited materials,
2. Restricted materials, and
3. Unprohibited materials.

Prohibited Materials

Twelve items are classified as prohibited materials from certain sources with exception and conditions, namely; plant pests, organic fertilizer, soil, rice, rubber, citrus, coconut, cassava, cotton, aquatic fern, Spanish moss and the transgenic plants. Importation of these materials are allowed only for research purposes with permission from the Director-General of Department of Agriculture. All imported prohibited materials must be thoroughly examined by the plant quarantine officer at the Plant Quarantine Sub-Division.

Restricted Materials.

Twenty seven plant species are classified as restricted materials such as soybean, mungbean, corn, sorghum, orchid, taro, wheat and etc. A Phytosanitary Certificate (PC) is required for the importation of restricted materials. Furthermore, importation of restricted materials, particularly plants intended for propagation are subjected to through examination by the plant quarantine officers at the Plant Quarantine Sub-Division.

Unprohibited Materials

Plant materials other than those classified as prohibited and restricted are unprohibited materials. Permission and a PC are not required for importation. However, they are subjected to inspection at the point of entry. All the imported plant materials must be destroyed if plant quarantine pests are found.

Unprohibited materials imported from SALB (South American Leaf Blight) areas must be thoroughly examined by the plant quarantine officers at the Plant Quarantine Sub-Division. Plant/plant materials must be sent directly to the laboratory for detection and identification of SALB spores. The packing materials must be destroyed and plants must be detained at the post-entry quarantine house for a certain period of time.

All imported plant quarantine objects must be inspected upon arrival. The diagram of the plant quarantine import procedure is shown in **Figure 1**.

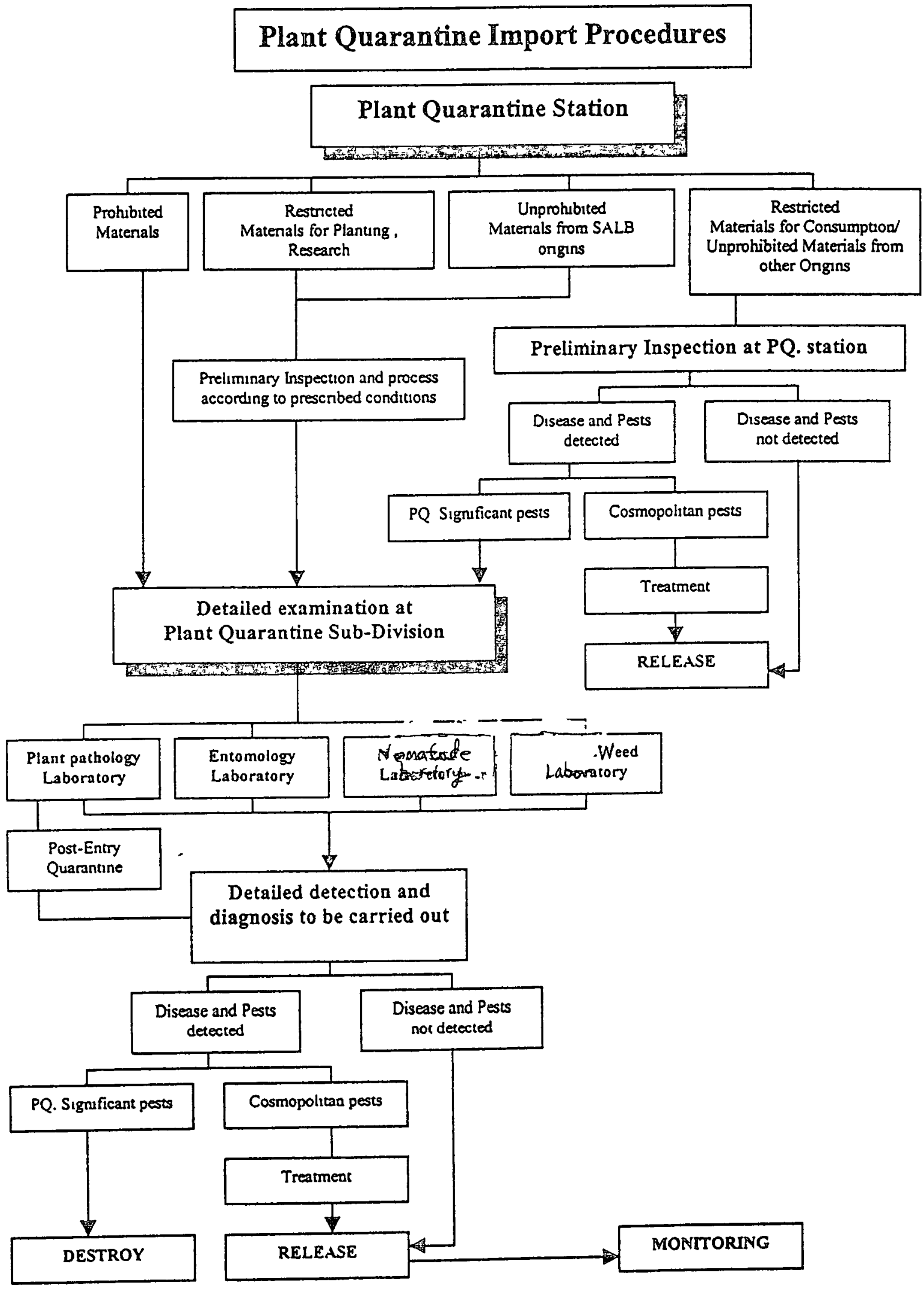

Figure 1. Diagram of Plant Quarantine Import Procedure

List of plant diseases and pests that pose the greatest threat

Disease/Pest	Common name	Host
1. *Microcyclus ulei*	SALB	Rubber
2. *Balansia oryzae-sativae* (*Ephelis oryzae*)	Udbatta disease /false ergot	Rice
3. *Xanthomonas campestris* pv *citrumello*	Black spot	Citrus
4. *Corynebacterium nebraskenes*	Leaf freckles and wilt	Maize
5. *Erwinia stewartii*	Stewart's wilt	Maize
6. Potato Spindle Tuber Viroid	PSTV	Potato,Tomato
7. *Fusarium oxysporum* f.sp. *lycopersici* race III	Wilt	Tomato
8. Maize Rayado Fino Virus	MRFV	Maize
9. Potato Virus Y (necrotic strain)	PVY	Potato
10. Coconut gadang-gadang viroid		Coconut
11. *Globodera rortrochiensis*	Potato Cyst nematode	Potato
12. *Globodera pallida*	Potato Cyst nematode	Potato
13. *Ditylenchus destructor*	Potato rot nematode	Potato
14. *Ditylenchus dipsaci*	Stem and Bulb nematode	Potato
15. Tephritidae	Fruit Flies	
16. Thripidae	Thrip	
17. Coccidae	Soft scale insect	
18. Diaspididae	Mealybug	
19. Acarididae	Mite	

The difficulties accurately identifying some disease agents and pests and reason in the following :

Disease/Pest	Reason for difficulty in identifying
Xanthomonas campestris pv *citrumello* *Corynebacterium nebraskenes* *Erwinia stewartii*	: No real specimens, lack of specialists, lack of technical skill in molecular techniques
Potato Spindle Tuber Viroid *Fusarium oxysporum* sp. *lycopersici* race III	: no real specimens, unreliability of current test, lack of specialists, lack of technical skill in molecular techniques
Maize Rayado Fino Virus Potato Virus Y (necrotic strain)	: no real specimens, lack of specialists, lack of technical skill in molecular techniques
Coconut gadang-gadang viroid	: unreliability of current test, no real specimens

Disease/Pest	Reason for difficulty in identifying
Tephritidae Thripidae Coccidae Diaspididae Acarididae *Globodera rortrochiensis* *Globodera pallida* *Ditylenchus destructor* *Ditylenchus dipsaci*	: No key, no real specimens, lack of specialists, no reference

Summary

Presently, the Plant Quarantine Act B.E. 2507 (1964) amended by Plant Quarantine Act B.E. 2542 (1999) has being enforced since 18th May 1999. The Act is administered by Department of Agriculture (DOA), Ministry of Agriculture and Cooperatives (MOAC). The Department has assigned Agricultural Regulatory Division to carry out various functions authorized by the Act. The Plant Quarantine Station and Plant Quarantine Sub-Division are two legal offices for plant quarantine services. Under section 6 of this Act, the Minister of MOAC has notified in the Government Gazette the name of eighty two species of microorganisms and pests that are prohibited in the Kingdom. The names of eighty two prohibited materials are the list of disease-causing agents and pests of national significant.

Plant Quarantine Sub-Division has conducting inspection, diagnosis and identification of diseases and pests of imported materials at the Plant Quarantine Laboratory Center. There are four laboratories for diagnostic diseases and pests in relation to particular causal organisms; Plant Pathology Laboratory (fungi, bacteria, virus, viroid and mycoplasma), Entomology Laboratory (insect and mite), Nematology Laboratory and Botany and Weed Laboratory. The suitable techniques for diagnosting diseases and pests are used in accordance with causal organisms. In case any technical problem occurred, there are another two supporting agencies, Plant Pathology and Microbiology Division and Entomology and Zoology Division which are specialized in their particularl discipline Furthermore, DOA also has technical collaboration in research and development with academic institutes such as Kasetsart University, Khon Khan University, and Chiang Mai University.

In plant quarantine laboratory center, the diagnostic techniques used are mostly general methods for fungi, bacteria, insects, mites and nematodes examination including viruses, viroids, and mycoplasma. Currently, we have initiated introduction of modern biotechnology for detection. The data collection of intercepted pests is recorded in MS Excel and summarized in a document as an annual report. In addition, the Exotic Pest database system is being developed.

The difficulties in identifying some diseases and pests especially in exotic or alien species are lack of technical skills in modern biotechnology, no real specimens for diagnosis, no pest identification key, irrelevant reference documents and lack of availability of PQ Pest Database Information System.

ANNEX 1

Plant Quarantine Pests List

Pests	Origin	Result
Fungi		
Ascochyta gossypii	All	Pests of Economic crops and Do not occur in Thailand
Balansia oryzae – sativae	All	"------------------------"
Deuterophoma tracheiphila	All	"------------------------"
Elsinoe australis	All	"------------------------"
Microcyclus ulei	All	"------------------------"
Pseudophaeolus baudonii	All	"------------------------"
Septoria citri	All	"------------------------"
Sphaceloma manihoticola	All	"------------------------"
Bacteria		
Xanthomonas campestris pv *cassava*	All	Pests of Economic crops and Do not occur in Thailand
Viruses		
Cassava African mosaic virus	All	Pests of Economic crops and Do not occur in Thailand
Cassava brown streak virus	All	"------------------------"
Cassava red mottle virus	All	"------------------------"
Cassava witches broom virus	All	"------------------------"
Cotton anthocyanosis virus	All	"------------------------"
Cotton leaf crumple virus	All	"------------------------"
Cotton leaf mosaic virus	All	"------------------------"
Cotton leaf mottle virus	All	"------------------------"
Cotton stenosis virus	All	"------------------------"
Cotton terminal stunt virus	All	"------------------------"
Rayado fino virus	All	"------------------------"
Rice hoja blanca virus	All	"------------------------"
Sugarcane ramu stunt virus	All	"------------------------"
Viroids		
Citrus cachexia viroid	All	Pests of Economic crops and Do not occur in Thailand
Citrus exocortis viroid	All	"------------------------"
Coconut cadang – cadang viroid	All	"------------------------"
Grapevine yellow speckle viroid	All	"------------------------"
Potato spindle tuber viroid	All	"------------------------"

Pests	Origin	Result
Mycoplasma		
Citrus witches broom MLO	All	Pests of Economic crops and Do not occur in Thailand
Palm lethal yellowing MLO	All	"------------------------"
Spiroplasma citri	All	"------------------------"
Sugarcane grassy stunt MLO	All	"------------------------"
Insects		
Anastepha fraterculus	All	Pests of Economic crops and Do not occur in Thailand
Anastepha ludens		"------------------------"
Anastepha suspensa	All	"------------------------"
Anthonomus grandis	All	"------------------------"
Anthonomus vestitus	All	"------------------------"
Artona catoxantha	All	"------------------------"
Bactrocera tryoni	All	"------------------------"
Ceratitis capitata	All	"------------------------"
Diatraea saccharalis	All	"------------------------"
Erinnyis ello	All	"------------------------"
Lissorhoptrus oryzophilus	All	"------------------------"
Opogona sacchari	All	"------------------------"
Oryctes boas	All	"------------------------"
Phenacoccus herreni	All	"------------------------"
Prostephanus truncatus	All	"------------------------"
Pseudotheraptus devastans	All	"------------------------"
Rhynchophorus palmarum	All	"------------------------"
Sacadodes pyralis	All	"------------------------"
Scirtothrips aurantii	All	"------------------------"
Sesamia calamistis	All	"------------------------"
Sesamia cretica	All	"------------------------"
Trioza erytreae	All	"------------------------"
Trogoderma granarium	All	"------------------------"
Mites		
Aceria sheldoni	All	Do not occur in Thailand
Mononychellus tanajoa	All	"------------------------"

Pests	Origin	Result
Nematodes		
Anguina tritici	All	Do not occur in Thailand
Aphelenchoides arachidis	All	"-------------------------"
Belonolaimus longicaudatus	All	"-------------------------"
Globodera pallida	All	"-------------------------"
Globodera rostochiensis	All	"-------------------------"
Heterodera avenae	All	"-------------------------"
Heterodera glycines	All	"-------------------------"
Heterodera graminis	All	"-------------------------"
Heterodera oryzae	All	"-------------------------"
Heterodera oryzicola	All	"-------------------------"
Heterodera punctata	All	"-------------------------"
Heterodera sacchari	All	"-------------------------"
Heterodera schachtii	All	"-------------------------"
Heterodera sorghi	All	"-------------------------"
Heterodera zeae	All	"-------------------------"
Hirschmaniella miticausa	All	"-------------------------"
Hoplolaimus columbus	All	"-------------------------"
Hoplolaimus indicus	All	"-------------------------"
Meloidogyne coffeicola	All	"-------------------------"
Meloidogyne exigua	All	"-------------------------"
Pratylenchus thornei	All	"-------------------------"
Rhadinaphelenchus cocophilus	All	"-------------------------"
Scutellonema bradys	All	"-------------------------"
Xiphinema americanum	All	"-------------------------"
Xiphinema index	All	"-------------------------"
Weeds		
Salvinia molesta	All	Noxious Weed of Thailand

Country Report

Diagnostic Services for Plant Quarantine in Japan

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1. Background of plant quarantine services in Japan

Japanese plant quarantine dates back to 1913 when an export Phytosanitary Certificate was provided for the plants destined for the USA. Then, next year, Japanese plant quarantine service was established by the promulgation of the "Export and Import Plant Control Law" (1914). After several amendments, "Plant Protection Law" was enacted in 1950. Japan is an island nation surrounded by oceans. The majority of pests entering Japan, therefore, are associated with human activities such as international trade and exchange of plants and plant products. Thus, it is imperative for Japan to regulate import plants and plant products in order to prevent the entry of exotic pests and diseases into the country.

In recent years, importation of plants and plant products into Japan is remarkably increasing in terms of the assortment as well as quantities. Kinds of plant commodities increased from ca.3,000 items to ca. 4,600 items during the last decade. Now, we are importing plant products from more than 160 countries. Such an increase of import commodities has also increased the risk of invasion of exotic pests and diseases. Innovation of means of transportation, both in terms of speed and capacity, further contributes to the viability and spreading potential of pests and diseases. Such situation necessitates a more reliable and rapid diagnostic methods for plant quarantine service in Japan.

2. Pests and diseases of plant quarantine significance

Pests and diseases that pose the great threat to our country are shown in Table 1. Import of these host plants into Japan is prohibited.

3. Diagnostic services

This service is managed by governmental budget. The head office of diagnostic service is one section of the research division of Yokohama Plant Protection Station. About 30 staff members (entomologists, nematologists and plant pathologists) work in this service at plant protection stations in Yokohama, Kobe, and Nagoya, among others. They give a technical information and advice for the plant inspectors to identify/diagnose the pests and diseases. Undiagnosed samples are, sometimes, sent to the head office.

4. Diagnostic methods

1) Microscopic examination

This is basically used for the identification of plant diseases, nematodes and insects, and is essential to diagnose the causal agents of fungal diseases. SEM is also used for nematodes (e.g. cyst) and fungi (e.g. smut). Skillful techniques and experienced staff are required to identify the causal agents.

2) Serological methods

These methods for detecting of pathogens, particularly plant viruses, have been available to plant pathologists. Immunological methods, because of their rapidity, high specificity, and high sensitivity, could be a possible solution for detecting the causal agents of plant diseases. In our service, methods such as ELISA are widely performed to diagnose the plant diseases caused by fungi (e.g. *Phytophthora*, *Pythium*), bacteria and viruses. Antisera used for ELISA tests are prepared by ourselves or purchased from a private company (domestic or foreign).

3) PCR

In recent years, molecular tests such as PCR are performed to diagnose the virus and viroid diseases, especially in post-entry quarantine. The utility of PCR for diagnosing fungal (e.g. *Fusarium solani* f.sp. *cucurbitae* race 1) and bacterial diseases (e.g. *Acidovorax avenae* subsp. *citrulli*) is currently being tested.

4) Others

In post-entry quarantine stations, various detection techniques available including inoculation test using indicator plants, EM and electrophoresis are performed. To identify the species of bacterium, host pathogenicity test and biochemical ones are performed.

5. Major constraints

In general, it takes a long time to identify causal agents of plant diseases. However, diagnostic results are required quickly in plant quarantine. Major constraints in the identification are:

1) Lack of information (key, references etc.) on exotic pests and diseases.
2) Lack of pest lists from foreign countries (exporting countries).
3) Lack of antisera for serological methods and specific primers for PCR.

6. Reference collection

Academic journals are available at the library of the research division of Yokohama Plant Protection Station. Scientific references can be obtained from the university or national research institute libraries. Digital information (e.g. CD) are introduced from foreign institute (e.g. CABI) and are being used frequently to diagnose pests and diseases.

7. Final summary

Diagnostic services for plant quarantine are currently carried out at plant protection station. A more reliable and rapid diagnosis is required. Therefore, a lot more information (pest lists, key, taxonomy, ecology etc.) on exotic pests and diseases is needed for accurate diagnosis.

Table 1. Pests and diseases that pose the greatest threat to Japan

Mediterranean fruit fly (*Ceratitis capitata*)
Oriental fruit fly (*Bactrocera dorsalis* complex)
Queensland fruit fly (*Bactrocera tryoni*)
Melon fly (*Bactrocera cucurbitae*)
Codling moth (*Cydia pomonella*)
Sweet potato weevil (*Cylas formicarius*)
Colorado beetle (*Leptinotarsa decemlineata*)
Lesser sweet potato weevil (*Euscepes postfasciatus*)
Hessian fly (*Mayetiola destructor*)
Potato cyst nematode (*Globodera rostochiensis*)
White potato cyst nematode (*Globodera pallida*)
Citrus burrowing nematode (*Radopholus citrophilus*)
Rice stem nematode (*Ditylencus angustus*)
Potato wart (*Synchytrium endobioticum*)
Tobacco blue mold (*Peronospora tabacina*)
Fire blight (*Erwinia amylovora*)
and other injurious pests and diseases not existing in Japan

AN OVERVIEW OF THE DIAGNOSTIC CAPABILITIES
IN THE PHILIPPINES*

*Bonifacio F. Cayabyab***

INTRODUCTION

A survey of 60 taxonomists in 23 developing countries highlights a committed professional identification service which is under resourced (BIGW2, 1999). The same holds true in the Philippines where there are very few systematists (18 active arthropods systematists) and most of the senior systematist are retiring or have already retired. Replacements of highly trained systematists are badly needed (Gapud 1984) but systematics is the least priority field of college enrollees.

It is imperative to upgrade the diagnostic capabilities in the Philippines to support government and private endeavors related to plant pest and disease management, sanitary and phytosanitary issues and biodiversity and conservation programs.

Philippine National Diagnostic Services

Government Sector

1. Museum of Natural History, University of the Philippines Los Baños
2. Department of Entomology, College of Agriculture, University of the Philippines Los Baños
3. National Crop Protection Center, College of Agriculture, University of the Philippines Los Baños
4. College of Veterinary Medicine, University of the Philippines Los Baños
5. Ecosystems Research and Development Bureau, College, Laguna
6. Institute of Biotechnology, University of the Philippines Los Baños
7. Department of Plant Pathology, University of the Philippines, Los Baños

Private Sector

1. International Rice Research Institute College, Laguna

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* Country report presented at the APEC Workshop to Contain Transborder Movement of Plant Pests: Diagnostics, The Bardon Centre, Brisbane, Autralia. July 3-6, 2001

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Professional Diagnostic Skills

PhD's, MSc's and BSc's on the following organisms are available in government and private sectors:

1. Nematodes
2. Bacteria
3. Fungi
4. Viruses
5. Arachnids
6. Insects
7. Mites
8. Plants
9. Rodents
10. Birds

Major Constraints

1. Lack of basic skills

There are very few taxonomists in the Philippines and many are retiring or have already retired. Few replacements with basic and advanced skills are available. Hence, young batches of taxonomists or parataxonomist should be trained on basic skills for identification/diagnostic works. Taxonomy is not a popular choice to student nowadays.

Microscopes are sorely lacking. Modern equipment for application of state of the art diagnostics are also wanting. As such highly trained taxonomist cannot fully utilize their diagnostic capabilities.

2. Lack of expertise in particular specialized techniques

Genetic identifications, immunoassays and other modern techniques for diagnostics are direly needed. A few taxonomists educated and trained abroad have returned to the country. However, with their heavy workloads, they cannot prioritize the transfer of skills on modern diagnostics.

3. Lack of identified reference and collections

Scarcity of reliably determined collections and references for identifying economically important groups except for rice, coconuts, stored products and others (Raros 1989).

4. Inadequate networking

Oriental systematists seem to distrust each other (Raros 1989). Biosystematic associations such as ASEANET can bridge the gap and promote cooperation.

5. Lack of taxonomic publications

Widely scathered and inaccessible taxonomic publications deters an interested beginner. Likewise the language used on original publications further compound the problem (Raros 1989).

6. Identification/diagnostics is not given much attention by policy makers

Policy makers are not aware or do not recognize the value of diagnostics. It comes to their consciousness only when unknown pest attacks crops of economic importance. The relatively new Bureau of Agriculture and Fisheries Products Standard is aware of the need for upgraded diagnostic capabilities. The current leadership of the bureau endorses and recommends participants from the government and private sectors to fora, seminars, and workshops on diagnostics and related fields. It also hired specialists/consultants to take care of crop protection matters including diagnostic works. The Bureau of Agricultural Research on the otherhand prioritizes the creation and capability build-up of diagnostic laboratories in the country.

State of the National Reference Collection

There is relative good national reference collections especially mites, aphids, true bugs and parasitic wasps in UP Los Baños, Museum of Natural History (Lit, pers. comm.) The said reference collections need to be resorted, remounted, recatalogued and reidentified. Unknowns should, likewise, be identified before the types are destroyed due to inadequate airconditioning and maintenance. Additional technicians should be hired and trained to take care of remounting. Specialist from other Philippine agencies particularly on various orders should participate in maintaining the national reference collections. Cabinets, preservation materials, pins and other laboratory supplies should be acquired.

Linkage with Other Diagnostic Providers

The Philippines is a member of CAB Biosciences. A few of the unknown agricultural pest and natural enemies where identified free of charge through the efforts of the Plant Quarantine Support Division, National Crop Protection Center. A training on diagnostics was also facilitated by the same division and entomologists participated by different regions.

We are also a member of the Southeast Asian (ASEANET) loop of the BioNet International. Initiatives on biosystematics in the ASEAN region is coordinated by the said loop. The National Crop Protection Center is one of the national institutes in the Philippines involved primarily on agricultural pest and natural enemies identification. It has informal linkages with the diagnostic centers in Europe, Asia, Africa and the USA.

Access to Diagnostic Technologies

The CABI Compendium and various manuals on identification for various orders of arthropods are being utilized. Modern techniques on diagnostics are employed at IRRI and some facilities of the University of the Philippines Los Baños but these technologies are generally limited to the said users.

Policy of Cost Recovery

The Department of Science and Technology (DOST) approved rates charges for diagnostic services in 1998. The values assigned for diagnostics are no longer applicable now given the cost of materials and equipment for diagnostics.

Consolidated List of Pest and Diseases

Pest management guides and manuals for various agricultural crops grown in the Philippines are available. Also there are checklists of arthropod pests (Gabriel, 1997) and diseases (Tangonan, 1999) of crops in the Philippines.

SUMMARY AND CONCLUSION

Diagnostics in the Philippines must be modernized to cope with the demands of plant health, consumers welfare, biodiversity and conservation. The major constraints of lack of basic skills and equipments, lack of specialized techniques, inadequate reference materials and publications, and lack of funds cannot be solved solely by a specific developing country. A concerted effort by the government and private sector with technical assistance from develop countries will ensure the upgrading of diagnostic in each country/economy in the region. Cooperation is an important requisite to effectively use diagnostics power and potentials.

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Appendix 1. List of Filipino Systematists

A. ARTHOPODS SYSTEMATISTS

Baltazar, Claire R.	Hymenoptera
Calilung, Venus J.	Aphidoidea
Corpus-Raros, Leonila A.	Acari
Magpayo, Fe	Diptera
Gapud, Victor P.	Heteroptera
	Auchenorrhyncha
	Odonata
	Coccinellidae
	Pachyrhynchini
Cayabyab, Bonifacio F	Rhopalocera, Quarantine Pest
Navasero, Mario V.	Psylloidea
Lit, Ireneo Jr L.	Coccoidea
	Bamboo Arthropods
Ballentes, Myrna G.	Hispinae
Reyes, Stephen G.	Hymenoptera
Barroga, Grace F.	Galerucinae
Recuenco-Adorada, Jessamyn D.	Coccinellidae
Reyes, Cecilia P	Thysanoptera
Eusebio, Orlando L.	Phasmatodea
Barrion, Alberto T.	Araneae
	Riceland Arthropod
Barrion, Adelina A.	Araneae
Sumalde, Augusto C.	Aleyrodoidea
Ruiz-Fiegalan, Elaida	Drosophilidae

B. PLANT SYSTEMATISTS

Rojo, Justo P.	Tree Legumes, Bamboos
Roxas, Cristina	Bamboo
Fernando, Edwino S.	Palms, Forest Trees
Aguilar, Norma O.	Legumes, Grasses
Tolentino, Danielo	Ferns
Gruezo, William SM	Lichens, Compositae, Gymnosperms

C. RODENTS AND BIRDS

Alviola, Pedro	Birds
Sanchez, Danilo	Rodents

Benigno, Edwin A.	Rodents
Hoque, Melanda M.	Rodents
Ocampo, Pablo P.	Rodents

APEC WORKSHOP TO CONTAIN TRANSBORDER MOVEMENT OF PLANT PESTS : DIAGNOSTICS
3-6 July Brisbane, Australia

SINGAPORE COUNTRY REPORT

By

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Animal & Plant Health Inspection Division
Agri-food & Veterinary Authority of Singapore

1. Background

Singapore is an island city state, with a population of 3 million people and a total land area of about 640 square kilometers. About 1,600 hectares of land is used for farming, 3,000 hectares are managed as forest reserves and 5,000 hectares are parks, gardens, recreational areas and green corridors. Although we are not an agricultural country, an estimated $722 million worth of agricultural exports and imports were facilitated through Singapore in 2000. The plant exports are mainly orchid cut flowers, ornamental and aquatic plants, fruits, vegetables and plant products such as spices and timber products. Inspections of the consignments and laboratory examinations for freedom from pests and diseases as required are carried out for the issue of export permits and phytosanitary certificates. Similarly plant quarantine inspections, and laboratory examinations for pest and disease status are processed for plant imports and to safeguard the plant health status of the garden city.

2. Plant Health Diagnosis

Plant health diagnosis for plant pests and diseases is largely under the purview of the Plant Health Diagnostic Services (PHDS) of the Plant and Animal Inspection Division of the Agri-food and Veterinary Authority of Singapore (AVA). AVA is the national authority to safeguard the animal and plant health of the country. It is the function of PHDS to provide phytosanitary and plant quarantine laboratory examinations to certify plant health status facilitating trade in plants and plant products; plant pest and disease diagnosis, identification, recommendation for control and management; and surveillance and monitoring of plant pests and diseases in the country.

PHDS consists of six plant health laboratories (Plant Pathology, Entomology, Nematology, Virology, Bacteriology, and Plant Nutrition) and a Pest Management Unit. This section besides catering to the diagnostic needs for phytosanitary and plant quarantine also serves the home gardeners, farmers, horticultural and landscape industries, golf courses and monitors plant pests and diseases.

Diagnostic capabilities in Entomology, Mycology and Virology are available at the Department of Biological Sciences, National University of Singapore, Institute of

Molecular Cell Biology and Institute of Molecular Agriobiology. However these are research and academic institutions that do not provide plant health diagnostic service for trade and economic plant products. No commercial or accredited plant diagnostic services are at present available.

3. Diagnostic Resources at AVA

a) Personnel

There are four plant health specialists at PHDS to cover diagnostic work on plant pest and disease diagnosis and identify insect pests, mites, fungi, bacteria, viruses and plant nematodes. The specialists are graduates trained in Entomology, Plant Pathology, Nematology and Virology. They are supported by three technical staff. Although without tertiary education training these technicians have accumulated expertise ranging from 3 to 30 years on the job experience and are of valuable assistance in the diagnosis of insects, fungi, bacteria and nematodes.

Staff are sent for short attachment training and short courses in specific areas when required or when available at institutes overseas.

b) Facilities

The diagnostic laboratories at the Plant Health Centre are in 2 buildings ranging 10-20 years old. The laboratories are well equipped with the basic diagnostic equipment to enable routine work, and are being maintained with up dated replacements when funds are available. Newer diagnostic equipment such as ELISA reader and PCR thermal cycler are part of the Virology laboratory equipment.

c) Technology

Methods used for various pest and disease diagnosis are summarised in the table below:

Diagnostic Laboratories	Identification Methods
Virology	ELISA, gel electrophoresis, PCR, indicator plants
Bacteriology	Culturing, microscopy, biochemical tests, BIOLOG
Mycology	Culturing, microscopy (morphological)
Nematology	Tissue & soil extractions, microscopy (morphological)
Entomology	Berlese funnel extraction, microscopy (morphological)

There is an on-going progress at adapting PCR diagnostic methods for selected fungi (*Fusarium oxysporum*, *Rhizoctonia solani* etc.) and also for fruit flies, *Ceratitis capitata* and *Anastrepha spp.*.

d) References

References to assist diagnostic work are from taxonomic keys and monographs, CABI Crop Pest & Disease Compendium (CD-ROM), distribution maps and information from internet access. PHDS has a small collection of about 2,500 insect specimen and 400 sheets of diseased plants herbarium. These collections are associated with the local economic pests and diseases of tropical vegetables, fruit trees and ornamental plants prevalent in the region. About 90% of the pests and diseases are identified.

Occasionally, insect pests and disease pathogens are sent to overseas institutions e.g. IIE and IMI at CABI for species confirmation. These are on a charged service contract basis that PHDS had with CABI. Other ad-hoc identification assistance for nematodes are from the ARS-USDA.

PHDS is in the process of compiling an updated Plant Host Pest and Disease Index for Singapore The last available information on a consolidated pest and disease list was from 1959 when Singapore was a part of Malaysia and shared the same list.

4. Plant Pests and Diseases of Economic Concern

Although Singapore is not an agricultural country, a portion of agricultural trade is facilitated through here for local consumption as well as re-export to the region and the world. Some 70 plant pests and diseases are identified as major economic concerns to the regional agri-trade and threats to plants here if unintentionally introduced and allowed to establish. Surveillance, pest risk analysis and likely eradication programmes are planned for some of these besides the plant quarantine measures taken.

Exotic pests and diseases that are identified to economically affect the vegetables, ornamental plants, orchids, trees, shrubs and plant products here are:

- Khapra beetles, *Trogoderma granarium*
- Mediterranean fruitfly, *Ceratitis capitata,*
- Mexican & S. American fruitflies, *Anastrepha spp.*
- Queensland fruitfly, *Bactrocera tryoni*
- Larger grain borer, *Protstephanus truncatus*
- Migratory Locust, *Locusta migratoria*
- Coconut beetle, *Oryctes monoceros*
- Cassava mite, *Mononychellus tanajoa*
- San Jose scale, *Quadraspidotus perniciosus*
- Palm wilt, *Fusarium oxysporum f. sp. elaedis*
- South American Leaf Blight, *Microcylus ulei*
- Red ring nematodes, *Rhadinaphelenchus coccophilus*
- Cadang cadang (viroid)
- Lethal yellowing (mycoplasma)
- Black rot of crucifers, *Xanthomonas campestris*
- Banana Bunchy Top (BBTV)

New or improved diagnostic technology for these would be needed to identify them in the surveillance and plant quarantine samples.

5. Needs and Constraints

AVA is concerned with the introduction of exotic pests and diseases that could affect agricultural production for the region, and the amenity plantings and forest reserves in the country. In the event that a suspected unwanted pest or pathogen is located, it is most likely that the taxonomic expertise on these foreign pests or pathogens would not be locally available. Significantly taxonomic specialists, technical skills, a quick access to relevant references and reliable diagnostic tools are needed. The high cost for identification services (for confirmation and reference collections) and costs in training staff abroad are heavy operating expenses for the diagnostic service.

A collaborative network (and electronic links) to other expert resources (regional and global) to share expertise and diagnostic technology would assist to spread expertise all round and would lower diagnostic expenses overall for all economies concerned. Regular and refresher training courses for technical staff in the identification and diagnosis of pests and diseases of regional concerns is greatly needed.

VIETNAM COUNTRY REPORT

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I. General Situation:

Vietnam is a member of Asia and Pacific Plant Protection Commission (APPPC), under FAO's auspices, and also has been the ASEAN's member since August 1995; now Vietnam is taking part in harmonization of Phytosanitary measures in order to join AFTA.

Having more than 3,570 km land borders with China, Lao, Cambodia and more than 3,000 km of coastline; Vietnam has established 42 Plant Quarantine Stations including 29 land border ports in Vietnam, 8 sea-ports, 3 international airport stations and 2 international railway stations.

Thanks to economic development in Vietnam and in the region, commercial activities in the borderline have increased sharply, contributing to commercial exchange between Vietnam and other countries, especially with the countries that share border with Vietnam. The Plant Protection Department of MARD is responsible for State management of Plant Protection and Quarantine activities. The organizational structure unite from central office to locality is given in Annex 1.

To prevent injurious pests associated with agricultural imports, the Plant Protection and Quarantine Authorities conduct inspection of imported commodities that may carry PQ pests. Nearly, more than 100 pests on in into Vietnam have been detected, some of them are Vietnam's PQ pests such as *Tribolium confusum, Trogoderma granaria, Trogoderma inclusum, Spongospora subterranea, Radopholus similis, Corynespora cassicola ...* (Annex 2)

<u>List of national diagnostic institutions:</u>

- National Institute of Plant Protection (NIPP - MARD)
- Vietnam Agriculture Science Institute (MARD)
- Agricultural University N° I - Hanoi ; Forestry Agricultural University - (Ho Chi Minh City), Cantho University
- Vietnam Agricultural Genetic Institute (MARD)
- Institute of Epidemiology and Hygiene (Ministry of Health)
- Institute of Ecology and Biological Resources
- Plant Protection Department (MARD)
- Central Plant Quarantine Laboratory
- Post Entry Quarantine Centre
- Technical Divisions of Plant Quarantine Sub Departments, but only PQ Sub Department N°2 is capable of meeting the diagnostic requirements.
- Identification capacities of Provincial Plant Protection Sub Departments are limited in terms of knowledge and equipment.

Government's policy issued:

The Government of Vietnam pays due attention to plant quarantine and develops the regulating system, guiding the implementation of plant quarantine activities:

- Ordinance on Plant Protection and Quarantine enacted by the National Assembly of the Socialist Republic of Vietnam on February 15th 1993. At present, the Ordinance is being revised.
- Plant Quarantine Regulation (Attached to Decree 92/CP November 27th 1993)
- Other regulations and decisions on plant quarantine.

Point of view:

- Conduct phytosanitary inspection of commodities according to contracts, L/C or International Agreements to which Vietnam is a signatory.
- Phytosanitary measures harmonious with regional and international countries.
- Conclude PQ Agreements with other countries in the region and in the world.

Lack of basis skills:

Vietnam in facing a lot of difficulties in implementing SPS Agreement and International Phytosanitary standards due to budgetary constrains and limited experience.

It is difficult to apply methods of diagnostic and quick identification practice not only in the border ports but also in laboratories of the above institutes and centers.

II. Possibility

- Although having a fairly good system to inspect imported-exported and transited plants, plant products and other pest carriers, the management of pest faces many difficulties in the border ports. At the PQ Stations inspectors can only do quick-test and apply methods of the PQ treatment when it is necessary for insect pests.

- Equipment is neither advanced nor sufficient, it is simple and not easily available. Therefore it is not easy to control pests and plant diseases at the border posts. A emerging problem in Vietnam is how to immediately have the right diagnosis in diseases that are caused by bacteria, virus, mycoplasma and phytoplasma.

- Don't have enough information, especially update of information on diagnosis and plant diseases control in the world.

- Some experimental techniques such as ELISA, PCR or molecular tests can only be carried out in few places such as NIPP, Agricultural University N°1 - Hanoi and Vietnam Agricultural Genetic Institute (not nation wide).

- We do not have software for pest risk analysis and list of objects that can not be imported.

Existing

Problem of exotic creatures:

1. Wood mimosa plant (*Mimosa pigra*) belong to *Mimosaceae* family, *Fabales* order has original resource from China, South America and was transported to Vietnam in 1970s. Up to now it has been used as fuel, for fence building, as a protection against breaking up the land, and as food for animals. At present, this plant becomes difficult to manage and makes trouble for agriculture. Recently, it's seeds in the stormy season followed the flood from Cambodia to Vietnam, and spread very quickly on a large area of agricultural land. On the other hand, it impaired fishing, transport, cultivation and increased water pollution by rotten trees. Up to now there is no successful and effective way to protect against this pest.

2. Powdery scab *Spongospora subterranea*: This is a Plant Quarantine Pest of Vietnam. Before, it had been detected in Germany and Scotland on potato. Years ago we detected the fungus on Chinese potato. In the year 2000 there were 41 lots of Chinese potato infested with this disease. Between Vietnam and China there are 15 border ports and 2 International Railway PQ Stations. Besides there are short cut ways that Vietnam PQ could not completely control. So, it is difficult to prevent infestation of the pathogen.

3. Fruit Fly: is a PQ pest of many countries blocking Vietnam from exporting fresh fruits. Nowadays, Vietnam is being helped by Australia and New Zealand through research projects to try the treatment of vapor of hot water.

III. Summary, recommendation

- Strengthening regional and international cooperation through technical projects.

- Training PQ officer as PRA, skill of prognosis ...

- Equip for PQ activities: All PQ Stations at points of entry should be provided with facilities for identification and treatment of fungi, bacteria, virus, nematodes and fruit flies.

- Information exchange on plant pests: Including their distribution within the countries, especially outbreaks of new pests should be immediately reported to the neighbouring countries to prevent pest infestation from imported plants, plant products and other carriers; to give control measures of pests with high probability of spreading across the border.

ANNEX 2

Plant Quarantine Pest of Vietnam detected in importing commodity 1993 - 2000

No	Pest	Detected								Commodity	From	Total
		1993	1994	1995	1996	1997	1998	1999	2000			
1	Tribolium confusum	3	7	9	31	16	10	9	11	Malt, wheat flour, cattle feed, bran	China, Uzbekistan, Australia	96
											Germany, Italia, SNG	
2	Trogoderma granarium	10	10	2	1	1	3	2	2	Bran, wheat flour, silkworm cocoon	Italia, India	31
3	Trogoderma sp			3	1	4					Uzbekistan, SNG	8
4	Trogoderma inclusum			7	2	6	5	7	5	Cotton, silkworm cocoon	Australia, Uzbekistan, SNG	32
											Tagikistan	
5	Pomacae sp		5	8	2						China	15
6	Acanthoscelides obtectus			1	1					Bean seed	Hongkong	2
7	Zabrotes subfasciatus				1					White cowpea	Hongkong	1
8	Stephanoderes hampei					1				Seed of melia plant	Philippine	1
9	Spongospora subterranea					1	1	4	41	Potato	Scottland, Germany, China	47
10	Corynespora cassicola							1		Ornament plant	China	1
11	Radopholus similis									Durian and other plants	Thailand	0
Total		13	22	30	39	29	19	23	59			234

Plant diseases/pests diagnosed

Fields / Method used	Identification of					
	Insect	Virus/Viroid	Bacterium	Fungus	Phytoplasma	Nematode
- Morphological taxonomy : CD-base key	Yes					
Direct/microscopy examination	Yes	Yes, only EM	Yes	Yes	Yes	Yes
Pest rearing procedure	Yes					
Immunological tests	Yes (NIPP)					
Molecular test	Yes (NIPP, NAGI)	Yes	No	Yes	Yes	No
Dot blots	No	No	No	No	No	No
Fingerprinting	No		No	Yes	No	No
Northern blots	No	No	No	No	No	No
PCR	Starting only(NIPP)	Yes (NIPP)	Yes	Yes	No	No
Indicator plants		Yes (NIPP)				
ELISA		Yes (NIPP)	Yes	Yes	Yes	No
Host pathogenicity tests			Yes			
Culturing			Yes	Yes	No	
Biochemical (species ID)			Yes			
Bioassay				Yes		
Pathogenicity /indexing					No	
Extraction from soil						Yes
Extraction from plant tissue						Yes
Other			Yes, by symptom	No	No	No
Test for specific		- Exocortis - X&Y-potato viruses - Ring spot papae	- Psoudomonas solanacearum - Xanthomonas oryzae, - Pseudomonas glumae - Erwinia sp	- Pyricularia oryzae - Fusarium spp	- Liberobacterium asiaticum (Greening disease of citrus)	- Meloidogyne on vegetable - Rotylenchus - Pratylenchus, etc

DAY 1 SESSION 3: ASSISTING DEVELOPING ECONOMIES IN SPS-RELATED MATTERS

- **Summary of country reports**
  (Dr Banpot Napompeth, ASEANET)

- **Plant health as a trade policy issue**
  (Dr Cheryl McRae and Mr David Wilson, AFFA)

- **Regional activities in diagnostics and related research**
  (Dr Paul Ferrar, ACIAR)

- **CBD and environmental issues**
  (Dr Ian Cresswell, Environment Australia)

PLANT HEALTH AS A TRADE POLICY ISSUE

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One year after taking office, the Australian Federal Minister for Trade, the Hon Mark Vaile, commented that "this past year has left me in no doubt that quarantine is an absolutely central trade policy issue for Australia".
Lunchtime address at the Quarantine and Market Access -playing by the WTO rules *forum, 6-7 September 2000, Canberra, Australia.*

Abstract

Plant health status has always influenced international trade. However since the establishment of World Trade Organization (WTO) in 1995, the plant health status of Member countries has become an integral part of import risk analysis via the disciplines of the WTO's SPS Agreement. It is now incumbent on Member countries to produce import risk analyses that are science-based, objective, defensible and transparent to support the imposition of sanitary and phytosanitary (SPS) measures The SPS Agreement builds on previous GATT trade rules to restrict the use of unjustified SPS measures for the purpose of trade protection while still acknowledging a country's right to determine the level of health protection it deems appropriate Now more than ever, plant health is a trade policy issue.

World Trade Organization and the SPS Agreement

The backbone of the international trading system is the set of rules that national governments have agreed to follow to ensure trade is non-discriminatory, fair, predictable and transparent. From 1948 until 1995 these rules were embodied in the General Agreement on Tariffs and Trade (the "GATT").

The Uruguay Round of multilateral trade negotiations under the GATT that started in 1986 resulted in the establishment of the World Trade Organization (WTO) in 1995. The WTO is now made up of over 140 Member countries and there are many more negotiating for membership. Unlike the GATT, the WTO has a legally binding dispute settlement system to deal with disputes between Members. The WTO Agreements include the old GATT agreement, and the basic principles underlying the GATT remain. However, specific rules now address a number of areas that were always problematic under the GATT, including trade in agriculture.

The Agreement on Agriculture prohibits the use of agriculture-specific non-tariff measures, such as import quotas and discretionary licenses, reduces the use of export subsidies and regulates the use of production subsidies that may distort trade. Two new agreements relating to quarantine rights and obligations and trade liberalisation also came into force with establishment of the WTO to complement the Agreement on Agriculture. The *Agreement on the Application of Sanitary and Phytosanitary Measures* (the SPS Agreement) and the *Agreement on Technical Barriers to Trade* (TBT Agreement).

The SPS and TBT agreements are themselves complementary. In broad terms, the SPS Agreement applies to measures whose purpose is to protect human, animal and plant life and health while the TBT Agreement covers all other technical regulations and voluntary standards, and the procedures to ensure that these are met. Therefore, the purpose of a measure determines whether the measure is subject to the SPS or TBT Agreement. It is the SPS Agreement that guides quarantine policy and decision-making.

The underlying objective of these Agreements is to ensure that governments do not use food safety and quarantine requirements as unjustified trade barriers in order to protect their domestic agricultural industries from import competition.

Scientific basis for SPS measures and risk analysis

The SPS Agreement confers both rights and obligations on WTO Members. Governments explicitly have the right to impose restrictions on international trade when these are considered necessary to protect human, animal or plant health from certain risks ie., governments have the right to impose sanitary (human and animal health) and phytosanitary (plant health) quarantine measures (Table 1). However, governments have an obligation to scientifically demonstrate that the trade restriction is necessary to protect health. In essence then, an SPS measure that restricts international trade is consistent with the SPS Agreement only to the extent that it is necessary to protect life or health and provided it is based on scientific principles and not maintained without sufficient evidence (Article 2.2).

Table 1: The definition of sanitary and phytosanitary measures

The SPS Agreement defines SPS measures as any measures applied:

- to protect human or animal life or health from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or foodstuffs;
- to protect human life or health from risks arising from diseases carried by animals, plants and their products, or from the entry, establishment or spread of pests;
- to protect animal or plant life from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms; and
- to prevent or limit other damage to a country from the entry, establishment or spread of pests.

Such measures include those taken to protect the health of fish and wild fauna, as well as of forests and wild flora.

The factors that shall be taken into account in the assessment of risks are available scientific evidence; relevant processes and production methods; relevant inspection, sampling and testing methods; prevalence of specific diseases or pests; existence of pest-or disease free areas; relevant ecological and environmental conditions and quarantine or other treatment (Article 5.2). Additionally, in assessing risks to animal and plant life or health, an importing country may take relevant economic factors into account (Article 5.3). These include the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease, the costs of control or eradication of an outbreak and the cost of programs to manage such responses, the costs associated with the loss of markets either nationally or internationally, and the relative cost-effectiveness of alternative approaches to limiting risks.

Factors that cannot be taken into account in risk assessment are less clearly articulated in the SPS Agreement. Nevertheless, while, not expressly excluded, factors including possible competition from imported commodities on domestic production and consumer benefits derived from trade cannot be taken into account in a risk assessment because they are not based on science.[1] These and other socio-economic factors can, however, be considered by a national government when it determines the level of quarantine protection deemed appropriate to protect the health of its people, animals and plants[2].

In order to provide a scientific justification for a trade barrier, the SPS Agreement requires governments to make use of internationally developed standards, guidelines and recommendations except where such standards do not exist or where a Member government determines that the relevant international standards are insufficient to achieve the level of sanitary or phytosanitary protection it considers appropriate for its circumstances (Article 3). For plant health, the relevant international and regional organisations operating within the framework of the Food and Agriculture Organization's (FAO) International Plant Protection Convention (IPPC) set the international benchmarks. The *Codex Alimentarius* Commission, a body jointly established by the United Nations FAO and World Health Organization (WHO) is responsible for food safety standards while the Office International Des Eqizooties (OIE) is the international standard setting organisation for animal health and zoonoses.

Governments that base their import requirements on international standards benefit from a legal presumption of having complied with the SPS Agreement. Governments, which do not use international standards, must be able to show that their SPS measures are based on an assessment of the health risks. The importing Member country must also, if requested, make known what factors it took into consideration and the risk assessment procedures used

Plant health status and risk analysis

Specific guidelines on how to undertake an import risk analysis of a plant commodity are provided by two of the IPPC's International Standards for Phytosanitary Measures - ISPM No. 1: *Pest Risk Analysis for Quarantine Pests* and ISPM No. 2 *Guidelines for Pest Risk Analysis*[3]. Regardless of whether or not the IPPC guidelines are followed, the starting point in any analysis is for the potential importing country's government to identify quarantine hazards

[1] **Pauwelyn, J. (1999).** The WTO Agreement on sanitary and phytosanitary (SPS) measures as applied in the first three SPS disputes, EC - Hormones, Australia - Salmon and Japan - Varietals. *Journal of International Economic Law*, 1999, 641-664; **Roberts, D. (2000).** The integration of economics into SPS risk management policies: issues and challenges. In: Anderson, K., McRae, C.F. and Wilson, D. (ed) (2001) *The economics of quarantine and the SPS Agreement.* Biosecurity Australia and Centre for International Economic Studies - Adelaide University, Australia.

[2] **Wilson, D. (2000).** The appropriate level of protection. In: *Quarantine and market Access - playing by the WTO rules.* Forum proceedings, 6-7 September 2000, Canberra, ACT, Australia, pp252, ISBN 0642455058.

[3] ISPM No.1 (April 2001) refers specifically to quarantine pests while ISPM No. 2 (1996) provides more general guidelines. These and other ISPMs can be found at the IPPC website: http://www.fao.org/AGP/AGPP/PQ/En/IPPCe htm.

that may be associated with the plant commodity. This means identifying pests[4] of quarantine concern and estimating the risk associated with each, referred to in ISPM No. 1 and 2 as "pest categorisation". To do this, the government must have access to accurate information about the plant pest status in its country and the country of the originating import proposal. Once the list of pests that are present in the exporting country but are either not in the importing country or if present are not widely distributed or under official control[5] is compiled, the risk of each is determined as a product of the probability of its entry, establishment or spread within the territory of the importing country and of the associated consequences[6] (see above regarding what consequences can be taken into account).

Plant health status, diagnostic capacity and trade policy

A WTO Member country requesting market access to another Member country (ie., submitting an import proposal) will be asked by the importing country to supply information about the plant health status within its territory. Information will include presence or absence of particular pests in the country, information about a pest's geographical distribution, its biology and its economic importance. It will not be acceptable to indicate that a pest is "not known to occur". Rather, evidence will need to be presented to support the assertion that the pest is "known not to occur" or is regionalised (see below). Similarly, the potential importing country must have be able to provide similar information about the plant health status of its territory. Collectively, this is part of the information that is needed by a WTO Member to meet its SPS Agreement obligation to scientifically demonstrate that a trade restriction (an SPS measure) is necessary to protect plant health.

Plant health diagnostic capacity underpins the capacity of a country to report on its plant health status and therefore is an integral component of import risk analysis, which determines plant commodity access to overseas markets. Effectively then, diagnostic capacity as the measure of plant health status is also a trade policy issue for both Member countries seeking access to overseas markets and those importing plant commodities.

Diagnostic capacity and regionalisation

Diagnostic capacity includes pest surveillance and monitoring capacity as well as taxonomic capacity including diagnostic tests used and specimen storage facilities such as herbaria and other collection systems. Pest surveillance and monitoring capacities take on extra significance in terms of trade facilitation because the SPS Agreement provides for the opportunity of regionalisation of trade by recognising that areas within a WTO Member's territory may be free from a pest or disease of quarantine concern or of low pest or disease prevalence (Article 6). Exporting Member countries claiming area freedoms must provide the necessary evidence regarding geographic distribution, epidemiology, eradication or control programs, inspection, sampling and testing methods to objectively demonstrate these claims to the importing Member country.

Further Reading

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[4] The IPPC defines "pest" as any species, strain or biotype of plant or animal or any pathogenic agent, injurious to plants or plant products.

[5] IPPC definition of a "quarantine pest".

[6] SPS Agreement, Annex A, no. 4, definition of a risk assessment

1. The World Trade Organization website - http://www.wto org

2. AFFA, (2000). Quarantine and market Access - playing by the WTO rules. Forum proceedings, 6-7 September, 2000, Canberra, ACT, Australia, pp252, ISBN 0642455058.

3. ANDERSON, K., McRAE, C.F. and WILSON, D. (ed) (2001) *The economics of quarantine and the SPS Agreement.* Biosecurity Australia and Centre for International Economic Studies - Adelaide University, Australia.

4. GASCOINE, D., WILSON, D and McRAE, C. F. (2000). Quarantine policy in the World Trade Organization environment. *Outlook 2000*, 171-178.

REGIONAL ACTIVITIES IN DIAGNOSTICS AND RELATED RESEARCH

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Introduction

Good diagnostic capacity is important for three main purposes:

- biosecurity – knowledge of what organisms are already present in your country, so that you can detect the incursion of exotics and take steps to combat them if necessary (also necessary for sound biological control, so that target species are correctly matched against effective natural enemies),

- trade and quarantine – under the SPS agreement countries exporting particular commodities must know what pests and diseases could affect those commodities, and must be able to prepare scientific documentation of this;

- biodiversity studies – surveys of the flora and fauna of an area, and how it changes over time (not directly relevant to this workshop, but useful to remember as a possible source of support, from global environment funds).

Two levels of taxonomic or diagnostic skill are needed:

- a standard level of ability to use existing knowledge to identify target organisms (which is all that is required in most users);

- a higher level of ability to sort out and classify previously undescribed organisms. Relatively few people have ability and training at this level.

Diagnosis may involve conventional methods, or molecular techniques, or often both. Conventional methods typically relate to morphology of various parts of the organism, or symptoms and morphology in the case of diseases; molecular techniques mainly involve ELISA and PCR techniques and variations of these. There has been a tendency in recent years for molecular techniques to be seen as replacements for conventional methods of identification, but they can rarely be used alone (except perhaps for identification of viruses). It is essential that diagnosticians learn to look at organisms as a whole, not just their genetic sequences.

Likewise it is also important that diagnosticians have the ability to look for and collect the target organism in the field, rather than just identify specimens presented or samples to be run through a PCR. Ability to survey is as important as ability to identify – the two go hand-in-hand for biosecurity and quarantine purposes.

Human capacity in diagnosis must be underpinned by several elements of infrastructure:

- **reference collections:** collections of pinned or alcohol-preserved insects, herbarium specimens of weeds, pathogen collections preserved by appropriate means; preferably databased for easy access of information. These are essential to support challenges to quarantine bans, when the identity of quarantine-relevant organisms may need to be proved;

- **reference information:** information on morphology, habits, host ranges, geographical distribution and molecular characteristics of all pests, diseases and weeds; methods for control or disinfestation. This is essential supporting information in making practical use of taxonomic information.

Capacity in, and needs of, the ASEAN region

At present there is only patchy capacity and knowledge in the ASEAN region, as indeed in all parts of the world. Governments regard taxonomy as "old-fashioned" and academic, and support for it is dwindling everywhere. At the same time the needs for these services are greater than ever before, for trade negotiations, for biosecurity and for monitoring environmental degradation (through biodiversity).

Each country has a number of experts on individual groups of pests, diseases and weeds, but not enough to service all of the country's needs. And there are many groups of pests for which no expertise exists at all. In the past the solution was to send specimens to overseas experts for identification, but this is now too expensive and often there are no overseas experts left because their support has been cut too.

It is beyond the scope of this paper to list the individual capacities of ASEAN countries, but it would be useful to have a survey by each country of:
(a) what relevant resources they currently have;
(b) what are the gaps that most urgently need plugging?

[I believe ASEANET may already have started doing this.]

Some initiatives already undertaken in collaboration with Australia

Australia (ACIAR, AFFA, AusAID) have already supported a number of initiatives with ASEAN countries to collect information and to enhance capacity and infrastructure. Among the ACIAR projects have been:

- surveys and diagnostics of fruit flies in Malaysia, Thailand and Bhutan, with work in Vietnam about to start (also Papua New Guinea, Fiji, Solomon Islands, Tonga, Vanuatu, Cook Islands, Federated States of Micronesia and Samoa in the South Pacific);
- surveys of whiteflies (especially the silverleaf whitefly, *Bemisia tabaci* biotype B) and associated geminivirus diseases in eight countries of Southeast and South Asia (and also in all South Pacific nations);

- surveys of bees and bee mites in Indonesia, Papua New Guinea and the Philippines;
- surveys and diagnostics of sugar diseases and pests in eastern Indonesia and Papua New Guinea; and
- surveys of and improved diagnostics for phytoplasma diseases of several crops in Indonesia, Thailand and Malaysia.

We have also produced a number of reference publications and other information sources to help the region. These include:

- several listings of pests and weeds of agriculture and forestry in different areas, ranked according to the importance of each pest and classified by country;
- reference books on individual pest species (insects and weeds), where they are found, and the prospects for their biological control;
- several CD-ROM products, including support for the CABI Global Crop Protection Compendium (which has information on many pests of crops worldwide); also a global guide to thrips;
- a computer package of information and training for quarantine officers in China (much interest now being shown by other countries, including Thailand and Malaysia, and other versions may later be supported); and
- an early attempt to develop a global database on viruses of plants (VIDE = Virus Information and Data Exchange).

I have listed the examples above so that participants can think of other initiatives of that type that Australia could help with in the future. We remain very willing to assist with this type of work, and are keen to learn which subjects would be priorities for ASEAN countries for future support. All the Australian agencies with capacity in this area have now formed a coordinating committee so that we can work together for the maximum benefit of our partner countries. We just need your inputs now.

One factor that will need careful and tactful consideration is the political aspects of operations such as surveys of pests and diseases in other countries. It could be felt that Australia might wish to survey (for example) fruit flies in a particular country simply to be better able to use quarantine bans to keep that country's exports out of Australia in the future. This has never been ACIAR's intention in any project, and we have worked to make sure that project information is not used in this way.

It will always be of benefit to countries to know exactly what pests and diseases are present in any commodities that they propose to export. The importing country will never accept that because nobody has ever surveyed the fruit flies of a particular fruit and there are therefore no records, it must then be safe to import it. The importing country is more likely to ban any imports until the surveys have been conducted. We are willing to help with this process of survey and diagnosis, and we can develop ways to avoid the possible perception of ulterior motives. In the long run, the more information that is available the better. If production of the information produces a problem for a country, then we should also work together to solve that problem.

The need for networking

The needs of the region for improved diagnostic capacity and better associated infrastructure are very large, and it will only be possible to do a small amount in coming years. To get maximum benefit from funds and efforts that are invested, it is very desirable to have some sort of networking in the region. An effective network could:

- help to share the resources that do exist in the region, to get maximum value from each; and
- prioritise the needs across the region to ensure that resources are invested first in the most urgent problems, and in the projects that will benefit the largest numbers of countries and industries.

The global initiative BIONET was established in part for such a purpose, and in Southeast Asia the ASEANET "loop" of BIONET is well placed to perform this function. Consideration should be given to how ASEANET can best carry out this task, and what resources they would need to do it.

Consideration should be given by all countries (perhaps coordinated through ASEANET) to the priority targets to be chosen for initial projects (surveys of pests and diseases, and better diagnostics for the problems). Every crop and commodity has a number of pests and diseases associated with it, and it will never be possible for all to be investigated fully. Priority should perhaps be given to:

- crops and commodities that are priorities as exports from the region (one or more countries); and
- individual biosecurity threats that are seen as particularly dangerous.

Conclusion

Diagnostic skills exist in the ASEAN region, but are limited and are insufficient for all the needs. Supporting infrastructure also exists, but is equally limited. Australia is looking for ways in which to help build up these capacities, but given limitations on the resources available it will be necessary to target the projects to the most urgent needs. The region could consider utilising ASEANET as a means of coordinating regional assessments and needs.

The Convention on Biological Diversity and environmental issues surrounding the transborder movement of potential invasive alien species

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I. Introduction

Currently at international and national levels there exists a range of measures that deal with invasive alien species in relation to their impact on biodiversity. These range from legally binding treaties to non-binding technical guidance provided for specific vectors. Most instruments are specific to a sector, taxonomic group, type of environment or type of harm i.e. injury to plant or animal health (CBD 2001).

The main global instruments are the Convention on Biological Diversity (CBD), Ramsar Convention, International Plant Protection Convention, Office International des Epizooties, United Nations Food and Agriculture Organisation, International Maritime Organisation and World Health Organisation. Regional instruments include the Bern Convention (Europe), Antarctic Treaty and South Pacific Regional Environment Programme. At the national level most countries have restrictions on introduction of alien species, but save for a few cases these are limited in scope and are not specifically designed to protect biodiversity against invasive species.

Significant differences occur between the quarantine/primary production and the environmental sectors in how alien species are dealt with, from terminological differences to the range of organisms covered. The only instruments that cover all aspects of invasive alien species in relation to biodiversity are the CBD and a few national systems. Generally taxonomic coverage is weaker for lower taxonomic categories (under conservation instruments). Existing instruments poorly cover alien freshwater aquatic species, and the coverage of pathways and vectors for unintentional introductions is patchy and usually non-binding (CBD 2001).

Generally it is agreed there is an urgent need to prevent unwanted introductions, and once introductions occur the issues of monitoring, eradication and control are exacerbated by few standard procedures and poor resourcing. While certain obligations exist within the current international environment and trade instruments little guidance is available on how these obligations might be met in practice, particularly at the regional level. Far greater attention is needed in monitoring and transboundary cooperation, if we are to deal effectively with the problem.

II. The Status Quo

While it is apparent that internationally coordinated effort is required to effectively prevent entry of invasive alien species, as well as to control species that do slip past our best efforts, this is currently not the case. Thirty-nine binding agreements are in force as well as a range of non-binding codes of conduct and guidelines that have all been developed for a specific purpose, and therefore have different emphases in relation to alien species (CBD 2001).

The CBD states that Parties should
"as far as possible and as appropriate, (to) prevent the introduction of, control or eradicate

those alien species which threaten ecosystems, habitats or species" Article 8(h).

The Convention on Migratory Species (CMS) terms alien species 'exotic species' and requires Parties to take prevention and management measures for those that may endanger migratory species. Under the CMS the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) provides detailed steps for dealing with exotic species in its legally binding action plan.

The UN Convention on the Law of the Sea (UNCLOS) requires Parties to take all measures necessary to prevent, reduce or control pollution of the marine environment resulting from the intentional or accidental introduction of alien or new species to a particular part of the marine environment, which may cause significant and harmful changes thereto (Article 196). UNEP Regional Seas Programme has specific requirements to prevent introductions to marine and coastal ecosystems for the Eastern African, Wider Caribbean, Southeast Pacific and Mediterranean regions (CBD 2001).

The International Plant Protection Convention (IPPC) provides a framework for international cooperation to secure common and effective action to prevent the introduction of pests of plants and plant products, and to promote appropriate measures for their control. The IPPC was revised in 1997 primarily in response to the adoption of the 1995 WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). The Office International des Epizooties (OIE) develops standards and guidance on pests and diseases of animals (but not animals themselves as pests) which are recognised under the SPS Agreement.

The International Maritime Organisation (IMO) has adopted *Guidelines for the Control and management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens* to assist Governments, ships' masters, operators and owners, and port authorities establish common procedures to minimise the risk of introducing harmful aquatic organisms and pathogens from ships' ballast water and associated sediments while protecting ship safety.

Many regional multilateral environmental agreements require Parties to regulate against introductions of alien species. The Bern Convention on the Conservation of European Wildlife and Natural Habitats and the Madrid Protocol of the Antarctic Treaty provide the strongest coverage against invasive alien species. The European Community and the Southern African Development Community (SADC) have measures in place for invasive alien species, though in the case of southern Africa these only extend to forests in the SADC Region (CBD 2001).

III. Gaps and overlaps in existing measures

Consistent terminology may be considered a gap in the overall approach to the invasive alien species issue. At present, there is no common language of relevant scientific terms and concepts for scientists, policy-makers and lawyers. Legal instruments at all levels use variable terminology inconsistently and/or without adequate definitions. A variety of terms are used in different sectors for alien species such as 'non-indigenous', 'non-native', 'exotic', 'foreign', 'new'. Those alien species that cause damage are called 'pest', 'weed', 'harmful', 'injurious', 'invasive', 'environmentally dangerous' (CBD 2001).

A further gap exists in the coverage of the various legal instruments as to what action triggers legal measures in relation to invasive alien species. For instance certain instruments only cover intentional introductions of alien species for release (sometimes limited only to a protected area).

Very few national systems cover all aspects of invasive alien species as they relate to biodiversity. More commonly, scope is limited to alien animals and plants and not lower order organisms, and rarely specifies coverage below the species level. The Madrid Protocol addresses alien micro-organisms, and the Bern Convention defines organisms belonging to non-native taxa (species or lower taxa) to include lower taxonomic categories, subspecies and varieties. Alien freshwater aquatic species are poorly covered under binding instruments anywhere in the world (CBD 2001).

Sanitary and phytosanitary instruments potentially cover all taxonomic groups and lower taxonomic categories, but they only cover these to the extent that these are injurious to animal or plant health as defined by the relevant instrument. While theoretically this covers environmental pests of wild plants it is not considered to cover harm to ecosystems per se, or plant genetic diversity (CBD 2001).

IV. What does the CBD require us to do?

The CBD concentrates on prevention, control and eradication, and the work done to date under the CBD has tried to flesh out the steps required to implement each of these strategies. In 2000 the Convention's Subsidiary Body on Scientific. Technical and Technological Advice (SBSTTA) developed Interim Guiding Principles for the prevention of introduction and mitigation of impacts of alien species. These guiding principles provide a range of high-level activities that start with prevention, and follow through a logical sequence of actions, from preventing establishment, containment and control, to eradication.

To effectively implement each of these principles requires a level of knowledge of what organisms are, and where they are from, that is, a detailed knowledge base, and monitoring.

4.1 Prevention

While it is generally agreed that prevention in the best possible measure against invasive alien species there is no consistency in how prevention should be implemented. The current global instruments provide a range of ideas of what restrictions should be imposed when and where, but are greatly reduced in effectiveness by lack of real-world data. What little practical criteria exist for implementing prevention measures would be greatly enhanced by easy-to-use diagnostic tools that would quickly ascertain risk, and from that provide a series of actions that could be followed.

Currently no general procedures exist for cooperation with the countries of origin of alien species, which if put in place would help engender better knowledge systems within the countries of origin, which would hopefully then provide useful information to countries ascertaining risk from alien species.

National customs and quarantine services provide the front line of defence, and are responsible for the major thrust of prevention efforts around the world. The current measures in Australia are world-class, but prevention requires 100% diligence from all parties not just regulators and enforcers if it is to be fully effective.

Currently international regulation under the IPPC is strongest for species designated as quarantine pests, which then require 'control' to contain spread after introduction. However if an alien species is not regulated as a plant pest then the IPPC provisions regarding measures applied to trade do not apply, and less action could potentially result (CBD 2001).

An example of prevention in Australia relates to the fungus known as Guava rust. No rust fungus has been described from eucalypts in their area of origin although several have been recorded on the genus overseas. Most of the reports appear to relate to occasional infections rather than to the development of a damaging 'new-encounter' disease. However massive infection of a range of eucalypt species has been recorded in South America by guava rust (*Puccinia psidii* G. Winter). Guava rust was recorded first from Brazil in 1884 on guava. Its present distribution is limited to Central and South America, Florida and the Caribbean.

This rust has become an important pathogen of eucalypts in Central and South America and the Caribbean. In these situations, epidemics of the pathogen cause substantial defoliation. This rust is a major quarantine concern to all regions where eucalypts are grown but especially to Australia where it would cause enormous damage to eucalypts in native communities, which of course would have both economic and environmental implications.

The likely pathways for entry of guava rust to Australia are via seeds, nursery stock, bark, lumber and wood packaging material including dunnage with attached bark. While we can identify these risks for transboundary movement, it is far more difficult to define the risks associated with **recognition**, (let alone transboundary movement) of many other potential environmental pests. Providing the needed tools to recognize something different and potentially threatening, along with the knowledge base that will actually be capable of defining whether an organism is indeed new, are major challenges we face across both agricultural and environment sectors in protecting our resource base.

4.2 Control

If we have lost the battle to prevent entry of some invasive species, we may still have the opportunity to control their distribution. *Bombus terristris* is an introduced bumble bee, now widespread in Tasmania. There is a strong lobby for its introduction onto the mainland of Australia as a pollinator of glass-house tomatoes (as a 'buzz' pollinator). Work on native vegetation in Tasmania shows that *Bombus terristris* visits flowers of (at least) 66 native plant species. It robs nectar from flowers of *Epacris impressa*, biting into the corolla and removing nectar without contact with anthers or stigma, having an adverse effect on seed-set (Hingston & McQuillan 1999). Research also shows that *Bombus* is likely to displace native bees, with consequent effects on pollen transfer in plant species (Hingston & McQuillan 1999). Another adverse effect attributed to presence of bumble bees is a dramatic increase in seed set in weed species. Control of bumble bees in those areas where they have become established is paramount for biodiversity outcomes elsewhere.

4.3 Eradication

Rapid identification of an invasive alien species once it has become established may allow swift action leading to its eradication. Perhaps the biggest impediment facing us here is the lack of knowledge of the native biota, so that we can definitively say that an unwanted incursion has become established and therefore would best be eradicated. Apart from our knowledge base and need for good identification tools, another limitation that can hamper quick, efficient eradication is the myriad of different authorities involved, and the time it takes to go through all the official processes. Determining that an organism truly is a threat, and clearly identifying who has responsibility for action requires new expert systems to be developed.

One success story in Australia relates to the giant African snail (*Achatina fulica* Bowditch), which is probably the most damaging land snail in the world. The normal food of the giant African snail is decayed vegetation and animal matter, lichens, algae and fungi. However, it will also eat a large variety of plants including most ornamentals, vegetables, and the bark of relatively large trees such as citrus, papaya, rubber and cacao. It is hardy mollusc with the ability to enter a dormancy period, enabling it to survive for long periods without food, and it has a rapid reproductive rate allowing it to colonize new areas very quickly. Although is a tropical snail, it can survive cold conditions, even snow, owing to its ability to lie dormant. Originally a native of Eastern Africa, the giant African snail owes most of its current wide distribution to spread by people. A 'hitchhiker' on virtually anything it can crawl onto, this snail is now widespread in the Indo-Pacific.

There was a small outbreak of giant African snails in Gordonvale, Queensland in 1986, but fortunately all of the snails were destroyed. During this outbreak in Queensland, the snail was commonly found during the day at the base of banana clumps, particularly on neglected plants where there was a large amount of leaf trash. Other common detection sites included under leaf litter, old roofing iron and timber, compost heaps, thickly grown ornamental shrubs and in crevices between rocks and tree roots. At night the snail was usually found in the open, often on barriers such as fences and house walls.

Once infested, very few countries have been able to eradicate this snail. On Pacific Islands it infests disturbed and native habitat. The Gordonvale eradication is one of the few success stories with this pest. Because the outbreak was confined to a relatively small area, an eight month long intensive campaign of community awareness, snail collection and baiting achieved the desired result of eradicating this serious pest. But would the effort have been so great if it had first established itself inside a national park?

V. Role of diagnostic tools

The old adage — prevention is better than cure Our best weapon in this respect is a well-informed front-line, equipped with diagnostic tools. ABRS aims to facilitate generation and dissemination of biodiversity information and seeks partnerships with user groups to develop diagnostic tools, such as identification keys and guides of various forms for community use.

Good tools will only ever be as good as our knowledge base, both taxonomic and ecological. The recent expansion of Yellow Crazy Ant, *Anolepis gracilipes* together with the lac scale insect *Tachardina aurantiaca*, on Christmas Island highlight the need for availability of identification tools, trained biologists and a sound biodiversity database.

It appears that the Yellow Crazy Ant was introduced unintentionally to Christmas Island between 1915 and1934. Over the last ten years, its range has expanded greatly. According to O'Dowd, Green & Lake (2001), it has formed 'super colonies', moving into the rain forest and feeding on the Red Land Crabs, occupying their burrows, and thus extirpating the dominant consumer on the island. With the explosion of the ant populations, the nature of the forest has changed. This has now been shown to be due to a synergistic relationship between the invasive ant and another invasive, a scale from SE Asia. The ant farms the lac scale, *Tachardina aurantiaca,* for its sugary secretions. The scale defoliates the forest canopy, light penetrates, causing growth of an under story, and modifying the forest (O'Dowd, Green & Lake, 2001). Much of the rain forest, previously thought to be resilient in the face of the alien ant species, has now been devastated, probably following the introduction and expansion of the scale population.

The Crazy Ant has since been intercepted a number of times at mainland Australian ports and recently established a foothold in Portsmith (Cairns), just a short step from the Wet Tropics World Heritage Area. Fortunately, it was eradicated.

VI. Conflicts between Environmental Outcomes and Production Outcomes

Finally we need to be well aware that conflicts will arise between the outcomes we are seeking to achieve across the biodiversity conservation and agricultural production sectors. For instance a study from Hawaii has recorded that 97 % of wasp parasitoids of Lepidoptera species are introduced species, some 94 % of them being species that had been introduced for biocontrol. In other studies, a number of parasitoid wasps appear to be out-competing native species, but for most there are no baseline data. However conclusive data exist for one study for which it has been possible to compare earlier and more recent data, that confirm that the introduced parasitoids are definitely displacing the native species (Bennett 1993). Without adequate baseline data we can become locked into adversarial roles of "defenders of our patch". With adequate data we can talk through sensible outcomes that minimise risk to all sectors of the community.

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DAY 1 SESSION 4: NETWORKING ACTIVITIES FOR REGIONAL DEVELOPMENT IN PLANT HEALTH

- Australian networking activities
  (Dr Ian Muirhead, CRCTPP)

- New approaches and technologies for plant pest diagnostics
  (Dr Rob Floyd, CSIRO Entomology)

- SPC-plant protection service diagnostic support activities
  (Dr Jacqui Wright, SPC)

- ASEANET - A regional network for taxonomy to support sustainability development in ASEAN
  (Dr Keng Yeang Lum, ASEANET)

Australian Networking Activities

Dr Ian F. Muirhead, Subprogram Leader, CRC for Tropical Plant Protection, Brisbane, Australia

Within Australia, the demand for sensitive, accurate, timely and cost effective diagnostic tests is increasing. Recent incursions of exotic insect pests and plant pathogens highlight the need for an effective national diagnostics capability. The demand for diagnostics for endemic pests and pathogens is also increasing as more emphasis is being placed on managing these problems in integrated systems with minimal use of agricultural chemicals. An accurate knowledge of the pest species present and the levels of infestation is critical in these systems. It seems that more is being asked of the current diagnostics system – which is largely State-based – every year.

Why network resources?

In this climate of increasing demand, it is tempting for public and private agencies to simply provide more resources for research and diagnostic service delivery. However several factors need to be considered carefully to ensure that resources are use most effectively. Some of these factors are general, and some are specific to Australia. Collectively, they present an argument for more effective networking. No single agency can effectively cover all of the issues.

The number of species for which diagnostic tests are required in Australia is very large

In Australia, crops and forest products are grown from the wet tropics to the cool temperate zone in high, medium, and low rainfall areas. The number and diversity of plant species used to produce these commodities is consequently high. Also, Australia is directing more attention to protecting its large and diverse native flora. The task of recording the pests and diseases already present, analysing the extent of exotic threats, and, developing strategies and diagnostic tests for protecting these species is potentially enormous.

Many agricultural industries are relatively small.

With some notable exceptions like wheat, cotton, sugarcane, bananas and grapevines, the gross value of many of our agricultural commodities, particularly in horticulture, is limited. This restricts the resources that growers of these crops can collectively devote to managing quarantine and related issues.

Diagnostic services are dispersed.

Australia's diagnostics services are dispersed sparsely around the perimeter of the nation in larger centres of population and agricultural production. This complicates effective communication.

Many diagnostic services are State-based.

State government departments provide many of the diagnostic services for Australia's agricultural and forest industries. From a national point of view, there is potential for duplication of effort in some commodities and under-servicing in others.

There is limited support for systematic and taxonomic studies.

In recent years, it has been difficult to gain resources to support the basic disciplines such at taxonomy which underpin an effective diagnostic services.

The benefits of new technologies

New molecular technologies are revolutionising diagnostics for human, animal and plant diseases and pests. Molecular biologists are providing new insights into genetic diversity within and between species, and a new generation of diagnostic tools is emerging. However it is sometimes challenging to understand the significance of diversity within pest and pathogen integrated in parallel with entomology and plant pathology in plant protection.

The development of networks in Australia

There are at least two initiatives that are leading to more integrated plant diagnostic services in Australia. Firstly, Plant Health Australia Limited, recently formed and combining the resources of plant industries and governments, has funded a survey of current diagnostic services throughout Australia. The survey is underway now and seeks to define the services available in both government and private industry. It considers the scientific resources that support these services, and the limiting factors. This "census" will provide basis information to guide future development and decision making at the national level. The Institute of Horticultural Development, Knoxfield, is conducting the work, commissioned through Plant Health Committee.

The second initiative is occurring within the Cooperative Research Centre for Tropical Plant Protection (CRCTPP). The particular problems associated with exotic pest incursions in northern Australia have been recognised for many years by AQIS through the development of the Northern Australia Quarantine Strategy (NAQS), by the Queensland Government through the Northwatch program, and by the Northern Territory and Western Australian Governments through their support for NAQS and their own programs.

The Centre for Tropical Plant Protection, funded in 1999, is a cooperative venture which combines inputs from the University of Queensland, CSIRO, Queensland Department of Primary Industries, Australian National University, Agriculture, Forestry and Fisheries Australia, Australian National University, Bureau of Sugar Experiment Stations, Northern Territory University, Northern Territory Department of Primary Industries and Fisheries, and the commercial company Rhobio. The majority of cash funding comes from the Commonwealth's CRC program, and extends until 2006. Of the two research programs in CRCTPP, one is focused particularly on protecting Australia's agricultural industries against exotic and endemic diseases and pests. A large part of this program concerns development of diagnostic tests, and supporting diversity studies.

One of the key strategies for the Centre is the development of the Northern Australian Diagnostics Network (NADN). This network has the support of the Agriculture Western Australia and thus combines the strengths of all of the major service providers in northern Australia.

Although the Network is still being developed, it has already made substantial progress. Some of the key developments over the last 18 months have been:

New Molecular Diversity and Diagnostics Research Laboratory

A new laboratory, funded by the Centre and Department of Primary Industries and opened recently by the Queensland Minister for Primary Industries, has been built at Indooroopilly. This is the centrepiece of the network. The laboratory houses a team of molecular biologists and support staff who work with specialists in plant pathology, mycology, virology and bacteriology. The diagnostic work is thus embedded in mainstream plant pathology. Delegates will visit this facility later in the week.

Priority setting

A Diagnostics committee drawn from representatives of all participating organisations in QLD, NT and WA establishes priorities for research on diversity and diagnostics. Targets are chosen on the basis of economic importance, quarantine significance, and technical feasibility. Current targets include:

Diversity studies – sugarcane smut (*Ustilago scitaminia*), tospoviruses of tomato and capsicum, Sporobolus spp.; and

Diagnostic tests – *Phytophthora* spp., *Fusarium oxysporum* f.sp. *vasinfectum*, *Mycosphaerella fijiensis, Acidovorax avenae*, Banana Blood Disease, *Ralstonia solanacearum*, downy mildews of grains and sugarcane, Banana Bunchy Top Virus.

Delivery of services

Already, tests including those for black Sigatoka and Fusarium wilt of banana (tropical race 4) have been used to manage very important disease outbreaks in northern Australia. Others such as those for *Phytophthora* species and fusarium wilt of cotton are under commercial development.

Strategy for delivery through the network

The strategy for delivery is to provide tests through the facilities and systems of the current service providers – such as DPI and NTDPIF in the case of black Sigatoka and Fusarium wilt of banana. The Centre is helping NTDPIF and DPI develop diagnostics laboratories in both Darwin and Mareeba, thus enhancing the network in northern Australia and providing regional delivery.

Resources

The network has gained support of Research and Development Corporations with both Horticulture Australia and Grains Research and Development Corporations funding major new project in 2001-2002.

Links to quarantine organisations

The Centre has close links to AQIS and the Office of the Chief Plant Protection Officer through AFFA, which is a core participant. Also, both the Northern Australian Quarantine Strategy and Northwatch are represented on the Diagnostics Committee. These organisations have a particular interest in northern Australia and neighbouring countries, and the Centre is assisting to develop diagnostics for the pathogens on the NAQS and Northwatch target lists.

Training

The Centre is delivering training through a number of routes, including a workshop on banana diseases organised by Crawford Fund and ACIAR.

Networking in the future

Depending on the outcomes of the current survey being conducted for Plant Health Australia, it may be appropriate for the Centre to develop an association with other diagnostics services currently operating in southern Australia. Such a national network should:

- Use the best technologies available world-wide
- Involve all major service providers in Australia
- Provide services in all disciplines
- Avoid unnecessary duplication, while providing for independent verification
- Be based on specimen, DNA and culture collections and an accurate knowledge of Australia's flora and fauna, and be databased nationally
- Be underpinned by research on systematics.

There are likely to be opportunities for networking in the APEC region, and perhaps even more broadly. The Centre for Tropical Plant Protection looks forward to exploring these opportunities this week and in the future.

New approaches and technologies for plant pest diagnostics

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There has never been a greater demand for accurate and rapid diagnostic services, which has in large part been stimulated by modern trade arrangements requiring import risk assessments and evidence of pest free status. At the same time, the resources being devoted to the maintenance and development of specialist taxonomic capabilities are slowly but steadily declining in Australia and around the world. The reduction in resources has led to reduced breadth of taxonomic skills, such that all the entomological taxonomic needs in Australia cannot be met within Australia but require access to specialists from other institutions around the world. Australia, or any other country for that matter, has never had a comprehensive set of taxonomic capabilities and so the current situation is only worse by degree.

The challenge to provide the taxonomic and diagnostic support required by trading countries can be met in two ways. Firstly, we need to work smarter by harnessing the power of a range of new technologies, and secondly, we need to work together to share expertise, data and knowledge. This presentation will focus mainly on the development of taxonomic capability and diagnostic tools that can be used by diagnostic service providers, not on the operational issues of providing a diagnostic service. It also is based mainly on considerations of entomology and not plant pathology; nonetheless the conclusions probably have broad application.

Working smarter

Before considering the significance of some of the new technologies used in insect diagnostics, it is important not to lose sight of the fundamental importance of morphological taxonomists and the traditional approaches to insect taxonomy.

Insect taxonomy has been based on morphological characters and the production of diagnostic tools generally taking the form of dichotomous keys. New technologies have augmented and changed the traditional approach in a number of ways as outlined below, however, examination and interpretation of morphological traits still remains the fundamental basis of insect taxonomy. Molecular data is an invaluable addition to the array of data used in taxonomic studies but has not and will not replace the need for morphological data. Furthermore, morphologists not only have the ability to make identifications of specific taxa and construct diagnostic tools for others to use, but also possess a wealth of knowledge of the general biology of their taxa of specialisation. The correct name of an organism is important, but only because it directs you to the accumulated knowledge of the biology of a species which is of immense value in risk analysis.

The advent of techniques to study the molecular biology and genetics of an organism has had a profound impact on the provision of diagnostic services. Molecular data provides a huge increase in the amount of data available for systematic analysis as well as allowing direct observation of the genetic change between related organisms. These data have been useful in resolving the phylogeny and determining the degree of relatedness of some taxa. This then provides a solid basis for the alpha taxonomy of specific groups.

In addition to aiding in the understanding of the phylogeny of particular taxa, molecular techniques have been used to provide rapid, cost-effective diagnostic tests to identify cryptic species or to identify life stages of organisms that do not possess adequate diagnostic morphological features. CSIRO have developed a simple test kit (Lepton ™ Test Kit) for the identification of *Helicoverpa punctigera* and *H. armigera* eggs using monoclonal antibodies. We have also developed a diagnostic system using polymerase chain reaction (PCR) primers combined with restriction fragment length polymorphisms (RFLP) to identify larvae or adults of some 80 species of endemic and exotic fruit fly from the genera *Bactocera, Dacus, Ceratatis* and *Anastrepha.* Producers and crop advisers use the Lepton™ Test Kit while the fruit fly methods were established for use by State government and Commonwealth quarantine diagnostic laboratories. Specific targeted test to determine the identity of taxonomically difficult species is a valuable use of the ever-increasing range of new molecular techniques.

The use of various information technology advances has dramatically changed the mode of presentation of identification tools. The construction of flexible electronic identification aids based on descriptive databases has been led by Australian scientists with the development of the DELTA, INTKEY and LucID software packages. Electronic keys based on data matrices allow the user to choose characters that are obvious and available to them rather than being forced to resolve specific couplets in a dichotomous key. These keys also have the added advantage of multimedia assistance with copious images and even video which can make possible the identification of difficult taxa by non-specialist workers.

Software and hardware for digital image capture and manipulation have greatly enhanced the capabilities of those developing paper-based or electronic diagnostic products. For example, a quality digital camera together with software such as *Automontage* enables sharp images to be constructed with full depth of field, thus reducing the cost and speeding up the production of taxonomic illustrations. Consequently, modern taxonomic products now tend to be more liberally illustrated and thus easier to use.

Key production software and image capture capabilities are bringing about a paradigm change in the method of publishing taxonomic tools. Paper-based dichotomous keys, in many cases, are giving way to electronic products published on CDROMs or directly on the World Wide Web. Decisions on the appropriate publishing method need to reflect the needs of the primary target audience and the information technology infrastructure available to them. The technology must continue to be the servant not the master of the product developer and client.

Working together

In an environment where diagnostic expertise is severely limited, even at the global level, it is essential that networks be established such that participants and clients can gain access to the necessary expertise for their diagnostic needs. For institutions such as the Australian National Insect Collection (ANIC) at CSIRO, there has existed for many years an arrangement of reciprocal access and assistance from the other major systematic entomology collections so that globally relevant taxonomic research can be conducted and the identification needs of each institution can be met. At the regional level, it is encouraging to see the effectiveness of networks such as the Pacific PESTNET email list serving as a useful forum for information exchange, assistance and even identification of specimens from images. The email list has subscribers from within the region as well as experts from abroad. Identification of specimens from images captured at locations remote from the expert is becoming more common as quality image capture systems proliferate.

At the national level in Australia, no single institution can meet all the insect identification needs of their clients. The ANIC has the broadest base of taxonomic expertise but is still unable to identify all specimens sent to it for determination. In recent months, significant impetus has been gained to establish a national network of collections for plant protection and quarantine research. This network consists of all State pest and pathogen collections and CSIRO's ANIC and is aimed at establishing a distributed national research facility that will enable the research required to meet the nation's diagnostic needs. Fundamental to this proposal is recognition that access to data, expertise and knowledge from the various nodes of the network is necessary to provide an effective national diagnostic capability. A logical extension of this concept is to establish similar functional networks on a regional basis. This is integral to the mission of BioNet International as evidenced in this part of the world through the establishment of the Southeast Asian (ASEANET) and Pacific (PACINET) networks.

Sharing of data by linking together databases of specimens or observations is another important element of working together. Various database products have been developed by different institutions to enable the efficient entry and retrieval of data. Database tools such as BioLink, developed by CSIRO Entomology, also provide a range of analytical tools that allow for spatial representation of data and even distribution modelling. BioLink databases can be easily linked to web pages to allow users to directly query the data. The recently launched website, Australian Ants Online (www.ento.csiro.au/science/ants/), is a good example of the integration of general information, specimen data and identification aids and is likely to be a model for future sharing of data and information.

There are currently many initiatives in Australia that aim to establish distributed specimen databases that can be queried from a central portal. Each of these initiatives requires software to be developed to link and query the databases. The National Pest and Disease Database (NPDD) is in the process of defining its data standards and operational requirements. The Online Zoological Collections of Australian Museums (OZCAM) is a zoological biodiversity equivalent to the NPDD and is at a slightly earlier stage of development. In addition, there are global initiatives such the Global Biodiversity Information Facility (GBIF) that have been established to facilitate the sharing of global biodiversity information. The future of these activities is likely to be the development of several web portals that provide users with the ability to query simultaneously a large number of databases containing quality data. This vision will be of great value to those responsible for quarantine and trade.

Although this presentation began with the sober recognition that financial resources allocated to taxonomic support for diagnostic services is declining, I believe that with the adoption of new appropriate technologies and the establishment of functional networks of taxonomic experts, the future is bright. Clearly we need sufficient specialists developing diagnostic tools and content for information rich electronic publications. All the best technology without the expertise and content will be of little value. We need to work together on a regional basis to support one another and share expertise, knowledge and data if we are going to meet the challenges of biosecurity and trading in this new millennium.

SPC-Plant Protection Service Diagnostic Support Activities

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Background
SPC comprises 22 Pacific Island governments or administrations and the five remaining founding countries: Australia, France, New Zealand, the United Kingdom and the United States of America. The mission of SPC is to provide technical advice, assistance, training and applied research to its Island member countries and territories. Requests carry government or administration approval, and are transmitted to the Secretariat via official country or territory contacts, ensuring that the organisation concentrates its efforts on priorities identified directly by its Island members. Also contributing to the formulation of the Work Programme are regional conferences and technical meetings, which gather specialists working in the region to ensure that SPC remains effective. The SPC-Plant Protection Service consults with three principal regional groupings within the agricultural sector, PHALPS (Permanent Heads of Agriculture and Livestock Production Services), Pacific Plant Protection Organisation (PPPO) and the Regional Technical Meeting for Plant Protection (RTMPP), to determine the needs and priorities for national and regional quarantine and plant protection services. Additionally, as a responsive service it provides a day to day advisory and information service. It also builds into its programme of work, emerging regional and international issues that are likely to impact on national quarantine and plant protection services.

recommended by PHALPS13 (1998, Guam), the SPC-Plant Protection Service (PPS) has focussed on achieving three strategic outcomes (3Ps) for the region:

- Prevention (quarantine and biosecurity activities which sustain the low pest status of the region);
- Preparedness to respond regionally and nationally to pest outbreaks to minimise the impact of new pest invasions on agriculture and environment;
- Pest management (the sustainable management of existing pests with minimal impact on public health and the environment).

Effective diagnostics support services are crucial to all three of the three strategic outcomes.

The SPC-Plant Protection Service is staffed by 2 plant pathologists (one is the Head of Service); 5 entomologists (two fruit fly entomologists; two general entomologists - one in Micronesia and one in Fiji; one taro beetle entomologist in Papua New Guinea); 1 technician taking care of the biocontrol laboratory; 1 information officer; and two information/extension assistants plus support staff.

Activities related to Diagnostics

1) Diagnostics Service.
A diagnostics network, rather than service is continually being developed by SPC-PPS. SPC-PPS has assisted two countries in the region to establish national databases into which their own data can be entered and will continue to assist any PICT (Pacific Island Country or Territory) with that request. Equipment and books are supplied on a request basis and also as materials for workshops. A newly established information and extension team disseminates plant pest information in a variety of ways including leaflets, posters, a website, an e-mail newsletter and CD-ROMs. SPC-PPS maintains a database of experts and does donor-funded support surveys and identifications.

There are two major projects that the SPC Plant Protection Service runs under:
- EU-SPC Pacific Plant Protection Service Project covering the 11 ACP and OCT countries in the region (i.e. countries in the Pacific that were signatories to the Lomé Convention and the French-speaking overseas countries and territories)
- AusAID/NZODA Pest Management in the Pacific project (whose various components cover the whole of the Pacific).

2) Surveillance.

Quarantine surveillance encompasses activities that assist in the early detection of unwanted pests and diseases and personnel involved in surveillance need rudimentary diagnostics capabilities. There is surveillance for fruit flies in all the countries of the region and each country carries out other surveillance according to its concerns with regard to pests. e.g. Taro beetle on islands in Fiji where it isn't currently present. The Fruit Fly Management project provides access to training for counterpart plant protection staff, for extension and quarantine staff, and for farmers and exporters in each country. This is achieved by running field demonstrations, workshops and seminars and making provisions for placement or attachment training. Also, the project introduced the system of using Junior Scientific Officers (JSOs) into Papua New Guinea to enhance national skills and ownership of the project.

3) Training in diagnostics.

Requests for training in plant protection and quarantine have been a regular occurrence for SPC-PPS. Training in one form or another has been conducted at the national and regional level. Plant protection and quarantine services have indicated that there is a need for more formalised training in plant protection and quarantine in the region. In early 2001, SPC decided to commission an independent feasibility study the objective of which was to conduct a feasibility study and develop a project rationale for the development and delivery of a certificate-level course in plant protection and quarantine. The report has just been completed and SPC-PPS will soon be acting on recommendations made by that feasibility study.

a) Plant Pathology.
SPC-PPS in collaboration with CABI has successfully run a basic plant pathology course in 8 countries. This workshop aims to increase plant pathology diagnostics capabilities and to

increase awareness of the achievable levels of investigation into crop disease diagnosis that could be accomplished with limited facilities, equipment and budgets. In two countries, a mini-disease survey was also run concurrently to train the participants in the field work aspect of diagnostics. Two Pacific Island plant protection staff attended a CSIRO workshop in nematode taxonomy and one Pacific Islander accompanied plant pathologists on a disease survey of Niue.

b) Entomology.
Two Pacific Island plant protection staff were sponsored by SPC to attend ANIC course on insect collection and curation.

4) Country visits and diagnostics services.

If there is expertise to diagnose a certain problem within the SPC-Plant Protection Service, that staff member will assist the country directly. SPC-PPS will access specialists to make country visits when necessary e.g. visit of New Caledonian fire ant specialist to Vanuatu. Between 1997 and 2001, SPC-PPS has processed over 250 insect identifications. SPC-PPS also supports country pest surveys for the maintenance of country pest lists.

5) Information support.

a) PACINET.
PACINET is the Pacific loop of BioNET and serves the needs of SPC member countries. It was developed to provide an effective means of identifying pests, transferring technology and knowledge and training experts in the region. It also aims to increase regional and would knowledge of the biodiversity in Pacific Island Countries and Territories (PICTs). PACINET provides information in printed form, CD-ROMS and through e-mail links. The South Pacific Regional Environment Programme (SPREP) is the Network Coordinating Institute (NECI) for PACINET and SPC-PPS collaborates with them.

b) SPC-PPS information support in a number of ways:

- **SPC-PPS Website.** This website keeps the region informed of plant protection and quarantine activities. http://www.spc.int/pps
- **Pacific Fruit Fly website.** This website is to inform the region on the activities of the Regional Management of Fruit Flies in the Pacific project (now named Fruit Fly Management project). It has an area for country input as well as providing information on pest fruit fly species. http://www.pacifly.org
- **SPC-PPS Pest Info newsletter** that is issued as e-mail and fax to those who have registered their interest. Pest Infos are informal notes of a 'news' nature with information about a specific activity, trial, or problem that is of relevance to either plant protection or quarantine or both. http://www.spc.int/pps/pest_infos.htm
- **Pest Advisory Leaflets.** Each issue of Pest Advisory Leaflet focuses on a single pest, covering diagnosis (identification), control and quarantine aspects. There are 37 leaflets published to date and many are also available in French. http://www.spc.int/pps/pest_advisory_leaflets.htm

- **Pest Alerts.** Pest Alerts contain information on new agricultural pest and disease outbreaks or other topical information on animal health and plant protection. There are 19 sent out so far. http://www.spc.int/pps/pest_alerts.htm
- **On request.** When a country contacts SPC, we will put that country in contact with a relevant expert, e.g. when a country requests diagnostics work on a suspected infection of Panama disease, SPC-PPS put them in touch with Dr Linda Smith, the INIBAP-recognised plant pathologist for diagnosing Panama disease.
- Through collaboration with FAO Ecoport, the successor to GPPIS (Global Plant and Pest Information System). http://www.ecoport.org/
- Through distribution of relevant diagnostics tools such as the SAFRINET CD-ROM: "SAFRINET Training Manuals for Entomology, Arachnology, Nematology, Mycology and Phytobacteriology". (For more information on this product see http://www.natmus.cul.na/safrinet/

Collaboration with other regional organisations

SPC-PPS is a cooperator on the Pacific Island Ecosystems at Risk (PIER) project being run by the Institute of Pacific Islands Forestry and funded by USDA Forest Service International Program. This project "compiles and disseminate reference information on exotic plant species of known or potential threat to Pacific island ecosystems, with particular reference to Micronesia and American Samoa. Included are plant species that are threats to natural or semi-natural ecosystems of all types; excluded are species that are agricultural, lawn and garden weeds."

SPC-PPS also participates by contributing information where relevant to a regional diagnostics e-mail network called "PestNet" that allows Pacific Islanders to write in with their problems and benefit from the experience of others in the region.

Pacific Island Countries and Territories Diagnostic Activities

The countries and territories within the Pacific are active in plant protection despite limited resources and staff for most of them. PICTs run their own surveillance programmes and their Research and Extension sections within the Ministries of Agriculture are active in pest management. Although some PICTs have trained entomologists and plant pathologists, respondents to the questionnaire overwhelming indicated that a lack of expertise was the main constraint to effective diagnostics services. Quarantine restrictions and irregularity of air services between Pacific Island countries means that specialists within the region can't be used because they can't receive samples to diagnose plant pest problems from other Pacific Island countries. However, SPC-PPS does send Pacific Island specialists on duty travel to assist other countries whenever possible. Strengthening of diagnostics capacity in Pacific Island countries and territories must continue for them to be successful in protecting their countries whilst maximising their full potential in trade and other sectors.

ASEANET – A Regional Network for Taxonomy to support Sustainability Development in ASEAN

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Introduction

ASEANET is the Southeast Asian Loop of BioNET-INTERNATIONAL, a global technical co-operation network for sustainable development through capacity-building in taxonomy. BioNET-INTERNATIONAL is made up of a series of interlinked sub-regional LOOPs (Locally Organized and Operated Partnerships) of scientific institutions. These LOOPs are dedicated to enabling developing countries to become realistically self-reliant in the skills of identifying and understanding the relationships of organisms which collectively constitute biodiversity and the living environment. It is a network of people and institutions designed to enable the pooling and sharing of existing taxonomic resources of the LOOPs and building further taxonomic capacity through institutional strengthening and human resource development.

BioNET-INTERNATIONAL - What, Why and Where ?

BioNET-INTERNATIONAL became necessary when, in 1993/94, the free taxonomic services, formerly provided by the expert centers of the developed world, were withdrawn and replaced by charges of US$100 or more per identification, which made it totally beyond the foreign exchange capacity of many developing nations.

LOOPs are designed to provide, through South-South co-operation and North-South partnerships, those taxonomic and related services that are essential for national programmes for sustainable agricultural development, conservation and sustainable use of the environment for the full implementation of the Convention on Biological Diversity (CBD).

LOOPs currently operate in the Caribbean (CARINET), East Africa (EAFRINET), West Africa (WAFRINET), Southern Africa (SAFRINET), and South East Asia (ASEANET). LOOPs have also been initiated in the South Pacific (PACINET) and East Asia (EASTASIANET). A consortium of expert centers in Europe (EuroLOOP) is also operational to assist in North-South co-operation.

Funding for BioNET-INTERNATIONAL is through a ten-year depleting capital fund with multi-optional contributory facilities for donors to sustain: a) network co-ordinating institutes and support services of LOOPs; b) central support services of the Technical Secretariat (TECSEC); and c) a BioNET-INTERNATIONAL Fellowship scheme.

ASEANET

Following a formulation workshop in Kuala Lumpur in 1996, ASEANET was formally established after endorsement at the Ninth Meeting of ASEAN Senior Officials for the Environment (ASOEN) in Singapore in 1998. All ten ASEAN member nations (Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam) are participating members of the network.

Implementation of South-South co-operation within ASEANET enjoys a good headstart with the close inter-country ties and existing linkages forged through the parent ASEAN grouping itself. Start-up activities have been made possible through the two-year grant from BioNET-INTERNATIONAL from funds provided by the Swiss Agency for Development and Cooperation (SDC). Activities are implemented through close collaboration and participation of the appointed National Co-ordinating Institutes (NACIs) and their respective country representative. The designated Network Co-ordinating Institute (NECI), the Malaysian Agricultural Research and Development Institute (MARDI), through the appointed Network Co-ordinator and the Secretariat at the CAB International SouthEast Asia Regional Centre (CABI-SEARC), co-ordinates all network activities as well as serves as the link to the parent BioNET-INTERNATIONAL.

At the ASEANET First LOOP Co-ordinating Committee (LCC) Meeting held in Kuala Lumpur in December 1999, members were unanimous that a comprehensive needs assessment survey should be undertaken to provide the necessary details on the specific yet different situations and needs of member countries, before implementation of the proposed work programme. This exercise is now considered a pre-requisite first phase of the overall work programme, providing important information necessary for its focused implementation. Four key components constitute the work programme; they are :

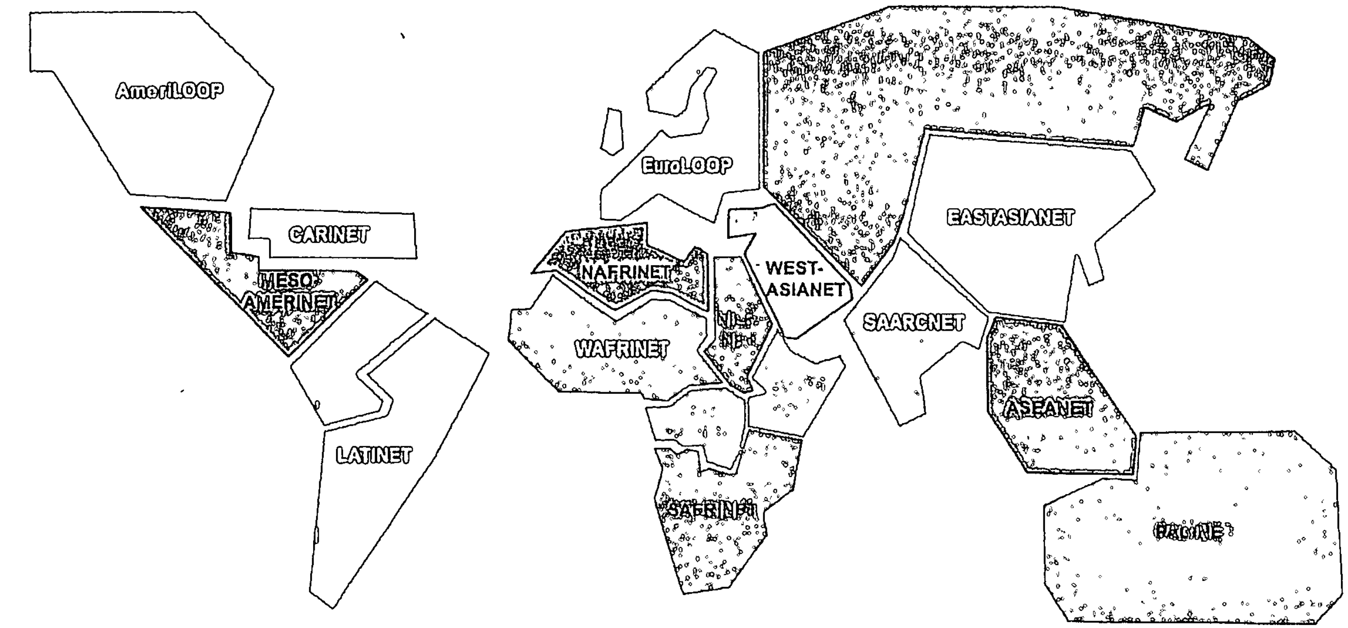
1. Development of Information and Communication (ICT) Services
2. Human Resource Development
3. Rehabilitation of Resources and Collections
4. Development and Application of New Technologies

ASEANET Activities

Since it became operational, activities initiated include fellowship training on the taxonomy and identification of parasitic Hemipteras and participation in two World Federation of Culture Collections (WFCC) training courses. A number of project proposals have been prepared and forwarded to various funding agencies for support. Proposals include the development of digital keys for insect pests groups, training in the use of software to build electronic taxonomic keys, training in the identification of insect pests, as well as new technologies in microbia identification

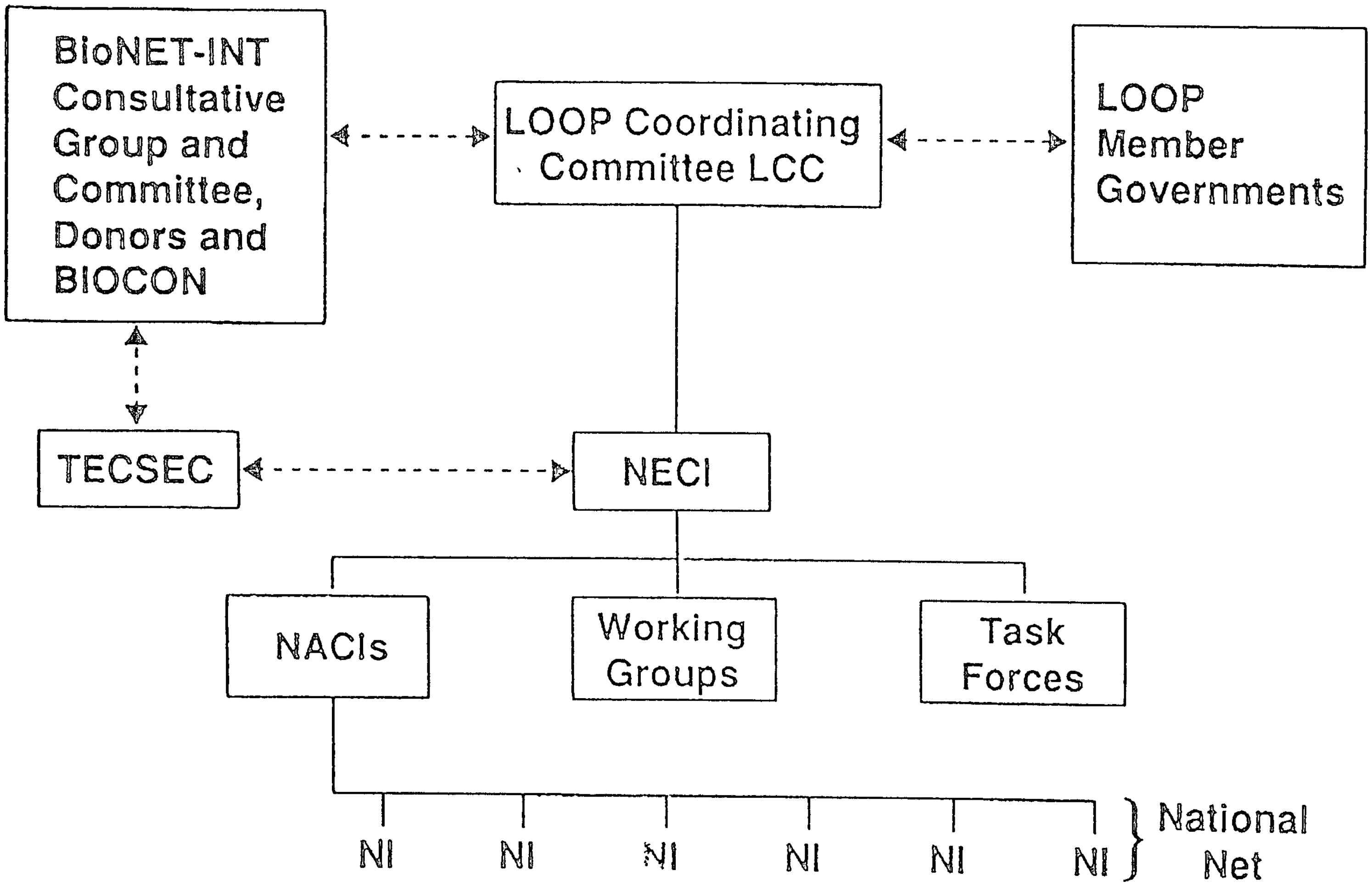
Proposals have also been submitted to the ASEAN Regional Center for Biodiversity Conservation (ARCBC) and the Japan Foundation seeking support for the major needs assessment exercise. A pilot concept paper on capacity-building in taxonomy has also been prepared for endorsement by ASOEN to be forwarded for consideration by the GTI/GEF.

BioNET-INTERNATIONAL
A GLOBAL TAXONOMY PROGRAMME
IN ACTION



- AmeriLOOP (Consortium of expert centres of US & Canada)
- ANDEANET (Andino pact countries)
- ASEANET (ASEAN - member countries) ✓
- CARINET (CARIFORUM countries) ✓
- CENTAFRINET (Central African countries)
- EAFRINET (Eastern African countries) ✓
- EASTASIANET (China (& neighbours))
- EuroLOOP (Consortium of expert centres of Europe) ✓
- LATINET (Southern Latin American countries)
- MESOAMERINET (Mexico & Middle America)
- NAFRINET (Africa North of Sahara)
- NILENET (Circa Northern Nile States)
- PACINET (South Pacific Islands & Mainlands)
- SAARCNET (Countries of the South Asia Association for Regional Cooperation)
- SAFRINET (SADC member countries) ✓
- WAFRINET (West African countries) ✓
- WESTASIANET (Arabian peninsular)
- CONCEPT STILL TO BE DEVELOPED

✓= networks already operational



Schematic structure showing governance and lines of management

DAY 2 SESSION 2 - REGIONAL SURVEYS

- **North Australia Quarantine Strategy (NAQS) plant health surveys**
  (Dr Richard Davis, AQIS)

- **Fruit fly surveillance in the South East Asian and South Pacific regions**
  (Prof Dick Drew, Griffith University)

- **Forest pest surveys**
  (Dr Ross Wylie, QDPI Forest Service)

Northern Australia Quarantine Strategy (NAQS) plant health surveys

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The Northern Australia Quarantine Strategy (NAQS) is a sub-program of the border operations group of the Australian Quarantine and Inspection Service (AQIS). NAQS was established in 1989 to address quarantine challenges unique to northern Australia. This part of the country is closest to neighbouring nations of differing plant and animal health status. In addition, the coastline is relatively unguarded and the population density is low. NAQS is divided into three sub-programs: NAQS scientific, operations and public awareness.

NAQS scientific conducts regular surveillance and monitoring to provide early warning of new and potential pest organisms that threaten Australia's plant and animal based industries and the natural environment. Most focus is on the coastal regions and islands of northern Australian that lie between Cairns and Broome. In addition, NAQS undertakes regular surveys overseas in collaboration with neighbouring governments.

Overseas surveys aim to detect new incursions of organisms of quarantine concern immediately to Australia's north. The areas surveyed are West Timor and Irian Jaya in Indonesia, East Timor, and those parts of Papua New Guinea (PNG) that lie close to the border with Indonesia and Australia.

NAQS Plant health surveys

Survey frequency The NAQS region in Australia is divided up into zones of perceived incursion risk and survey frequency is adjusted according to risk status. Risk calculations consider geography, levels of human activity, density of agricultural production, and prevailing winds. The highest risk areas are contain other island of the Torres Strait and these are surveyed twice each year. Although [illegible] zones lying within 20 km of the sea, some areas considered to be at special risk in land are also included.

Survey targets Target lists of plant diseases, insect pests and weeds have been compiled and are regularly updated. These are useful survey tools as they provide an initial indication of the higher risk pests (of crop and non-crop hosts) that may be encountered on survey.

Survey protocol As a result of risk analyses, NAQS plant health surveys are generally undertaken in areas of human habitation or visitation. In remote communities in Australia, this means the survey team (botanist, entomologist and plant pathologist) spend much of their time inspecting domestic gardens (after asking for permission from residents). Gardens with a good range of 'food plants' are prioritised and larger plantings such as community farms are also visited. Overseas, most time is spent examining plants in subsistence and cash cropping systems. Overseas surveys rely heavily on the Quarantine and Agricultural Departments of the collaborating country for success.

Specimen collection and identification

Conventional identifications At each survey location, representative specimens are collected and treated in various ways to ensure quarantine risk is minimised. From surveys in areas of differing quarantine status (for example the islands of the Torres Strait and overseas), most botanical and insect specimens are returned in alcohol. Most collections of suspected plant pathogenic fungi are returned as dried and pressed herbarium specimens and are subjected to fumigation or irradiation upon return. Such specimens are suitable for direct identification, based on morphological characteristics. This is done by NAQS scientists in collaboration with taxonomic experts in Australia and overseas. Vital to success is close liaison with national and state curators of botanical, entomological and plant pathology collections. However there are many plant pathogens as well as some insects, for which such identification methods are not possible.

Diagnoses of plant diseases using other methods Early NAQS plant disease surveys resulted in extensive checklists of fungal pathogens (Hyde and Alcorn, 1993, Hyde and Philemon, 1994, Shivas *et. al,* 1996)). In these reports however, no intracellular pathogens and only a small number of plant pathogenic bacteria were identified. This may have been a result of difficulties experienced in returning good quality fresh plant samples from remote locations to diagnostic laboratories. In the NAQS program from 1997 onwards, a number of sampling methodologies were adopted to overcome this problem. They allow return of material highly suitable for testing using serology and/or the tools of molecular biology.

Intra-cellular pathogens (viruses, phytoplasmas, phloem limited bacteria) As these pathogens can not be cultured, morphological studies are of limited value. Instead, identification is achieved using various serological assays (such as Enzyme Linked Immunosorbent Assay (ELISA) or Immunosorbent electron microscopy) and/or the tools of molecular biology (such as polymerase chain reaction (PCR) and analysis of amplified DNA sequences)

On NAQS surveys, plant samples thought to be infected by intra-cellular pathogens are returned for such analyses after rapid desiccation in the field. To do this, specimens (about 1 g fresh weight of young leaves or shoot tips) showing disease symptoms are first surface sterilised in 1 % available chlorine to eliminate organisms that may be present on external surfaces. The material is then rinsed in water, blotted dry and chopped finely The sample is desiccated over anhydrous calcium chloride (about 7g) in sealed plastic vials (25 ml in volume). The key to success is to ensure minimal production of cell degradation products (which turn the tissue brown/black in colour) as these will interfere with diagnostic procedures performed later. This is best achieved by keeping the vials stored at 4°C until all moisture has been removed from the plant cells. Once fully desiccated, samples can be stored at -20°C.

Black Sigatoka disease of banana Confirmation of the presence of the causal fungus, *Mycosphaerella fijiensis* on suspect lesions on banana leaves has often been unreliable using light microscopy. The presence or absence of *M. fijiensis* in banana leaves found on NAQS surveys is now routinely determined using excised lesions treated as described above in a PCR diagnostic test.

Bacteria Conventional testing for bacterial pathogens requires the establishment of cultures which may pose an unacceptable quarantine risk in some cases. Certain high risk bacterial pathogens can now be identified using the tools of molecular biology. Non infectious bacterial DNA can be obtained by incubating bacterial cells in the lysis medium of Gillings and Fahy (1993). This is made from 200 µl TNE medium pH 7.6 (100 mM NaCl, 100 mM EDTA (pH 8.0), 25 mM TRIS (pH 7.6)) plus 50 µl 20% (w/v) SDS and 50 µl buffer saturated phenol.

The collection methods outlined above have been employed on NAQS surveys since late 1996. Much of the material collected was forwarded to researchers in the Cooperative Research Centre for Tropical Plant Protection (CRCTPP) for diagnostic testing. Many tests were also undertaken by NAQS staff in Mareeba, with technical guidance and backup provided by the CRCTPP. The results of this ongoing collaboration are records of several bacterial, plus numerous virus and phytoplasma infections of plants. Amongst these, some key outcomes are summarised in table 1.

Identification of insects using the tools of molecular biology

PCR-based diagnostics are now being used to identify larvae of insects of quarantine concern. This would be of particular value when it is not possible to rear larvae through to adults for identification by conventional means. Suitable targets include larvae of fruit flies and certain moths (Lepidoptera).

Future developments

There are a number of diagnostic research projects currently being undertaken by the CTCTPP that are of extreme value to the NAQS program. Work that aims to improve diagnostic tests for black Sigatoka, fusarium wilt and bacterial wilt diseases of banana, as well as several important plant viruses are now in progress. NAQS is liaising closely with these researchers.

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Table 1. Highlights of recent NAQS plant disease surveys, achieved using non conventional collection and identification techniques

Disease	Pathogen	Diagnostic	Key finding	Reference
Blood disease of banana	"The blood disease bacterium"	PCR from BLM[a]	First confirmation in Irian Jaya (also New Guinea)	Davis et al (2000a)
Citrus huanglongbing (greening)	"*Candidatus* Liberibacter asiaticus"	PCR from desiccated leaf petiole/midribs	First confirmation in Irian Jaya (also New Guinea)	Davis et al (2000b)
Rice tungro	*Rice tungro bacilliform virus*	IEM[b] from desiccated leaf	First confirmation in Irian Jaya (also New Guinea)	Davis et al (2000c)
Black Sigatoka	*Mycosphaerella fijiensis*	PCR from desiccated leaf	Incursion at Bamaga, Qld	Davis et al (2000d)
Banana streak	*Banana streak virus*	IEM and iPCR[c]	First record in New Guinea	Davis et al (2000e)
Citrus canker	*Xanthomonas axonopodis* pv. *citri*	PCR from BLM[a]	Confirmations in PNG and Irian Jaya	Davis et al (2000f)
Witches' broom of *Planchonia careya*	CAWB Phytoplasma	PCR and RFLP[d] from desiccated leaf petiole/midribs	First record of a phytoplasma in a native tree in Australia	Davis et al (2001)

[a]Bacterial lysis medium
[b] Immunosorbent electron microscopy
[c]Immunocapture PCR
[d]Restriction fragment length polymorphism analysis

Fruit fly surveillance in the South East Asian and South Pacific regions

By: Professor R.A.I. Drew, Griffith University, Australia

Introduction

Fruit flies are the major insect pests of horticultural industries in most countries from temperate to tropical environments. Because of the severe damage caused through crop losses and the loss of export trade through quarantine restrictions, fruit flies are major targets for quarantine services in many countries.

There are three areas of quarantine that can be used to reduce the risk of introduction of new pest species to a country –

1. Off-shore quarantine where imported commercial fruit consignments are guaranteed to be fruit fly free as a result of a post-harvest treatment at the source of supply
2. Border quarantine through detection systems at ports of entry, particularly for travellers entering the country
3. On-shore quarantine through the application of specific detection systems to provide early warning of new introductions.

In this paper I discuss the latter strategy i.e. on-shore surveillance. For countries like Australia, assisting our neighbouring countries to establish their own fruit fly quarantine surveillance provides return benefit in reducing the introductions and spread of major pest species throughout the region and therefore into Australia.

History of fruit fly surveillance within Australia

It is worth reflecting on the history of fruit fly quarantine surveillance within Australia so that we may learn from what we have done.

In 1976, Allan Allwood (an Entomologist within the Northern Territory Department of Primary Industries) and I successfully sought support from the Australian Plant Quarantine service to establish a northern Australian quarantine fruit fly survey. The aim was to detect any introduction of exotic fruit flies, particularly from the northern and northwestern sectors of our region. The Oriental Fruit Fly complex species were the major target through a trapping network that was set from Broome in the north west of Western Australia to Cairns in Queensland. Each State department i.e. Western Australia, Northern Territory and Queensland, conducted the survey within its own borders.

With the appointment of quarantine entomologists and pathologists to the State departments in the early 1980's, the program was expanded and become known as Northern Australia Quarantine Strategy (NAQS). Two significant decisions were made that directly affected the efficiency of the fruit fly survey –

1. A broad target list of plant pests and diseases was established. At one stage this included some 200 species, and quarantine staff were expected to survey for these.
2. The fruit fly survey was downsized to only a few mainland sites and the Torres Strait islands. Coastal Queensland towns such as Cairns were excluded.

Although there was an increase in funding to this expanded quarantine survey in the early 1980's, the money was spent on staff housing, computer networks for databases and other general facilities.

Consequently, when the Asian Papaya Fruit Fly was introduced into the Cairns region of northern Queensland in 1993, it was not detected until late 1995, by which time it was well established over several thousand square kilometers.

<u>Why survey for fruit flies</u>

Annually, we hear of more major fruit fly species being spread across international quarantine boundaries. Some recent examples are –

Bactrocera dorsalis (Hendel), established in Tahiti in 1997 and in Mauritius in 1996

Bactrocera papayae Drew and Hancock, established in PNG in late 1992, Torres Strait island and Cairns in 1993

Ceratitis capitata Wiedemann, established in Auckland in early 1996

Bactrocera zonata (Saunders), established in Egypt in 1996.

In addition, there are even more examples of introductions that have been detected but have not resulted in established outbreaks.

Clearly, major fruit fly species will continue to break through quarantine barriers. The most efficient system to counteract this is to have early warning through well planned fruit fly surveys based on trapping with some associated fruit collecting. Early detection ensures that rapid, low-cost eradication can be carried out successfully.

The current status of fruit fly quarantine surveillance in our region

Within Australia

The NAQS fruit fly program continues to run at an efficient level. There are 125 male lure traps over 50 sites on 21 islands in Torres Strait and 13 sites around the northern coastline in Cape York This survey is currently of great importance in providing data on the *B. papayae* incursions into the Torres Straits. When detected, eradication treatments are promptly administered.

During and after the *B papayae* outbreak in north Queensland, quarantine surveillance traps were established across most States. These were used to guarantee trading partners that the States were free of *B. papayae* and other major exotic pest species. Currently, there are some 420 traps in 140 sites throughout Queensland, serviced on a 2-weekly basis. It is essential that these surveys are maintained at an efficient level because Australia will experience more incursions of exotic pest species.

South Pacific Islands

Since 1995, fruit fly surveillance programs have been established in 21 Pacific Island countries (see Table 1 below). They are based on male lure trapping and in most countries have been well maintained. The surveys were set up through Australian Centre for International Agricultural Research (ACIAR) projects and the South Pacific Regional Fruit Fly Project. The Australian project teams conducted regular and intensive training workshops so that maximum benefit could be obtained for the quarantine services in each country. The training included identification of major exotic pest species, systems of quarantine surveillance, aspects of fruit fly ecology important to quarantine surveillance and pest risk analyses.

TABLE 1 – Quarantine trapping network for exotic fruit fly pest species in the Pacific Region

	COUNTRIES	NO. TRAPS
MICRONESIA		
1	Northern Mariana Islands	20
2	Guam	40
3	Palau	122
4	Fed. St. Micronesia	60
5	Marshall Islands	8
6	Kiribati	20
7	Nauru	66
MELANESIA		
8	Papua New Guinea	134
9	Solomon Islands	70
10	Vanuatu	126
11	New Caledonia	98
12	Fiji	246
POLYNESIA		
13	Tonga	50
14	Niue	50
15	Tuvalu	28
16	Tokelau	6
17	Wallis & Futuna	12
18	Samoa	50
19	American Samoa	18
20	Cook Islands	62
21	French Polynesia	654

Currently, we are working on a PNG Fruit Fly Project funded by AusAID through ACIAR. We have conducted specific surveys of travellers in order to estimate the chances of pest fruit fly species being carried from PNG to neighbouring islands and countries. Also, we are currently assisting PNG to establish a permanent quarantine fruit fly survey. Again, the establishment of the surveys is accompanied by training programs.

Although these South Pacific quarantine surveys are of great value to the countries in which they are operated, they also have real benefit for Australia. If we can maintain countries such as PNG, Solomon Islands and Vanuatu free of major exotic pest species that threaten Australia, the chances of such species entering Australia are reduced.

The economics of fruit fly surveillance

Early detection of fruit fly incursions ensures eradication over a short time period for quite small expenditure. For example, the medfly outbreak detected soon after establishment in Auckland in March 1996 was eradicated in 2 to 3 months for a cost of approximately $300,000. In contrast, the *B papayae* outbreak in North Queensland, undetected for 2 to 3 years, took 3 years to eradicate at a cost of $34 million. In addition, there are enormous costs to industries through loss of trade, when exotic species become well established and take long periods to eradicate.

It is fortunate that fruit flies can be detected efficiently through male lure trapping. Surveys based on this method are extremely low cost, probably in the order of $250/trap/year which includes materials and labour in the field and laboratory.

Conclusions

No country can afford not to have a thorough quarantine surveillance program for early detection of exotic fruit fly species. The need for such surveys is ever increasing when we note that more species of fruit flies are being distributed by travellers, each year. Fruit fly surveillance is economic common sense. Some importers of fresh horticultural produce e.g. New Zealand, have a motto for exporting countries, "no surveillance, no trade".

For maximum efficiency in quarantine surveillance, I believe that we should have small target lists of major insect pests and diseases. We should concentrate on the small number of major pests that, if found, can be eradicated with significant cost-benefit to Australia. Large target lists merely withdraw our resources and attention from the major threats.

Forest Pest Surveys

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Forest trends

The area of the world's forests, including natural forests and forest plantations, was estimated to be 3 454 million hectares in 1995 (FAO 1997) (Figure 1). Of this, about 43% are located in developed countries and 57% in the developing world, which is for the most part tropical. Looking at changes in forest cover, between 1980 and 1995, 200 million hectares were lost in the developing world, mainly for agriculture. This is an area the size of Indonesia. During the same period, 20 million hectares were added in the developed world through reforestation and natural regrowth on failed agricultural land. The current annual loss of 13.7 million hectares is an area the size of Nepal. Conversion of forest land to agriculture, particularly in developing countries, is likely to continue as the world population increases.

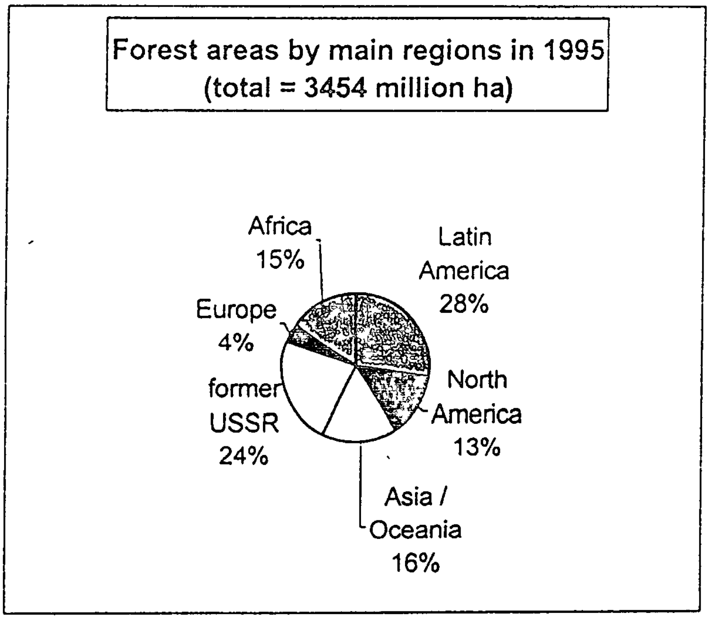

Figure 1. Forest areas by main regions in 1995 [from FAO (1997) State of the World's Forests]

Although forest plantations currently make up only 3% of the world's forests, their areas are increasing rapidly to meet the need for industrial wood. Such plantations also have the potential to allow reduced levels of harvesting in the natural forests. In the period 1980 to 1995, the area of plantations in the developing world doubled from about 41 million to 81 million hectares, most of this in Asia (Figure 2). An estimated 57% of that area is planted with hardwood species (principally eucalypts and acacias) and 43% with softwoods (various species of pines).

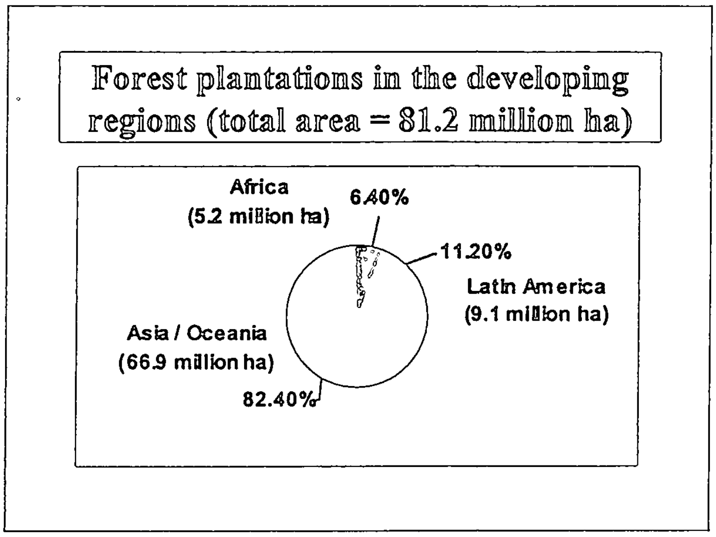

Figure 2. Forest plantations in the developing regions [from FAO (1997) State of the World's Forests].

This valuable resource is under increasing risk of serious pest damage from both indigenous and exotic pest species (Wylie 1992, Wylie and Floyd 1998). The nature of these threats in the Asia/ Pacific region, and a means of reducing the risk through structured surveillance are discussed in this paper.

Pest threats from within-country

The massive expansion of the plantation estate in Asia in recent years has involved the use of a relatively few tree species, and these are mainly exotic. For example, in the southern Chinese provinces of Guangdong and Guangxi, almost three-quarter of a million hectares of *Eucalyptus* species have been planted since 1980, and there are about half a million hectares of *Acacia mangium* planted on the Indonesian island of Sumatra alone. Many of these plantings represent even-aged monocultures, a circumstance that is causing some unease among forest managers in the region. As well, the plantations are expanding into new areas with a new suite of potential pests. Some of the sites are marginal for good tree growth, and pest problems associated with stressed trees may be expected. There is evidence that indigenous insects are gradually adapting to the exotic trees as hosts. In southern China over the period 1987 to 1991, the number of indigenous insect species recorded feeding on eucalypts increased from 96 to 167 and levels of damage by identified key species also increased (Wylie 1992). Most of the pest insects recorded by Wylie *et al.* (1998) during surveys in eucalypt and acacia plantations in Malaysia, Indonesia, Thailand and Vietnam over the period 1997 to 1999 were indigneous. New and potentially serious pest problems are constantly emerging, such as the recurring attack over the past several years by mosquito bugs on eucalypts and acacias in northern Sumatra (Wylie *et al.* 1998), and by a longicorn beetle on plantations of *E. camaldulensis* and *E. tereticornis* in south Vietnam (Wylie and Floyd 1998).

Another example of an 'internal' pest threat is the situation where a damaging species is established in one part of the country and may be spread to other parts by movement of goods and materials. Such a situation exists in the Philippines where the bark beetle *Ips calligraphus* is present in the main island of Luzon and has caused severe damage to *Pinus* plantations there, but is not known to occur on the other Philippine islands.

Threats from exotic pests

The threat posed to the forest resources of APEC countries by exotic pests, while broadly acknowledged, has yet to be properly defined in most instances. Very few detailed pest risk analyses (PRAs) for the forestry sector have been undertaken in the region. One example is that conducted by Floyd *et al.* (1998) of *Eucalyptus* spp. at risk from incursions of plant pests through Australia's northern borders. That PRA was mainly focussed on countries immediately to the north of Australia (Papua New Guinea, Indonesia, Malaysia and the Philippines) because of proximity and the amount of human and trade movement. However, potential pests from other countries were considered, particularly where pathways existed for possible incursions. In the course of the PRA, a database was compiled with over 2500 records of eucalypt insect pests belonging to 920 species. Assessments were made of the quarantine risk posed by each species based on a combination of factors including the likelihood of entry, and of successful establishment and spread, and the potential to cause serious damage. Ten key pest genera or species were rated as high or medium risk to Australia (seven of these are from Asia) and have now been targeted by the Australian Quarantine and Inspection Service.

As highlighted by Wylie and Floyd (1998), the preponderance of Australian tree species used in industrial forest plantations and woodlot plantings throughout Asia and the Pacific signals the need for an urgent assessment of the pest risks from Australia to that region. To date, very few Australian insects have been recorded on plantation trees in APEC countries but the possibility for spread exists, as evidenced by some of Australia's more notorious pest exports such as gum tree longicorns and eucalyptus weevil. There are several Australian insect groups that may be of importance for Asia/ Pacific, especially where currently there seem to be vacant niches or that taxonomic group is represented minimally. Examples include sawflies, lerp-making psyllids, several chrysomelid and scarab defoliators, and certain genera of longicorns and wood moths.

Several high-profile forestry pests are already established in some countries in the region, and vigilance is required to prevent their further dispersion. Examples include pine wilt nematode (in Japan, Korea, China), pine shoot moths (Vietnam, China, Philippines), *Ips* bark beetles (Philippines, China, Australia), and Asian longicorn (China). The vector of pine wilt nematode, *Monochamus alternatus*, was recently detected post-quarantine in Brisbane, Australia, having entered via wooden pallets from China and is currently subject to eradication measures. *Hypsipyla robusta*, a serious shoot-borer pest of high-value Meliaceae, was last year detected for the first time in Vanuatu. Such pest poses great risk to the valuable mahogany plantations in neighbouring Fiji.

The importance of forest pest surveys

Formal systems of forest health surveillance are in operation in several countries around the world but there are few examples in the tropics. Such a structured system has many benefits. Its main purpose is the early detection of potential pest problems, whether from exotic or indigenous organisms. The earlier the detection, the greater the range of management options available for dealing with the problem. Data are accumulated on insect distribution, hosts, biology and impact. The database provides a history of the health of the forest estate, down to the level of individual compartments. It is a valuable tool for research and management in setting priorities and formulating strategies for preventing or minimising pest impacts. It also provides an inventory of the forest fauna, which is an essential step in determining the establishment status of a discovered organism, and whether it is indigenous or exotic. In the context of this Workshop and of the disciplines imposed by World Trade Organisation Agreements on the Application of Sanitary and Phytosanitary Measures, such surveys provide key benefits to countries seeking WTO membership.

Progress in implementing a forest health network in the Asia/Pacific region

Day *et al.* (1994), in their review of Asian tree pests, expressed concern about the lack of quantitative data on pest impacts and the difficulties of obtaining up-to-date pest information. These issues are seen as major hindrances to the recognition of pest problems and the identification of research priorities in the region. Other recognised needs are for scientific training, assistance with taxonomy, preservation of biological collections, data management and networking with other scientists.

In tropical Asia, over the period 1997-1999, a collaborative project funded by the Australian Centre for International Agricultural Research (ACIAR) was conducted to begin addressing some of these issues. Participating countries were Indonesia, Malaysia, Thailand, Vietnam and Australia. Systematised investigations were made of the current status of insect pests in plantations of tropical eucalypts and acacias in these countries, with the aims of

1. determining the key pests occurring on these trees;
2. reporting on insect distribution and impact on plantation health and growth;
3. developing procedures and networks which can form the basis for ongoing pest assessment in the region.

The surveys were conducted across a range of eucalypt and acacia species, provenances, ages, geographical locations, site conditions and times of year using standardised data collecting methods. Overviews were obtained on pest problems for each country as described in Wylie *et al.* (1998) and the information already used in the formulation of a Pest Risk Analysis (Floyd *et al.* 1998).

A proposal to develop similar forest health surveillance systems in the Pacific region was presented to a meeting of Heads of Forestry of Pacific Island States and Territories last year (Wylie *et al.* 2000) and received enthusiastic support. Funding for this work is currently being sought. The ultimate aim is for the establishment of a forest health network across Asia and the Pacific, with participating countries all employing similar surveillance methodologies, databasing and reporting, and sharing information on forest pest and disease problems and forestry quarantine to mutual benefit.

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DAY 2 SESSION 3 - OVERVIEW OF DIAGNOSTIC SCIENCE

- **Overview of diagnostic techniques**
  (Dr Margaret Schneider, CRCTPP)

- **Diagnostic Services for Plant Industries**
  (Dr Peter Merriman, DNRE)

- **Commercial delivery of root pathogen testing: A tool for disease management**
  (Dr Felice Driver, C-Qentec Diagnostics)

- **DNA-based diagnostics of insects**
  (Dr Glenn Graham, UQ)

- **Quarantine bacterial pathogens**
  (Dr Mark Fegan, CRCTPP)

OVERVIEW OF DIAGNOSTIC PROCEDURES

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This paper presents a brief overview of current approaches to diagnostics rather than an overview of the specific techniques used in diagnostics. The content of the paper evolved from initial discussions between Gimme Walter and me and then later with Ian Muirhead and some quarantine entomologists when we were developing an approach to entomological research within the CRC for Tropical Plant Protection (CRCTPP). This research is of an identification and diagnostic nature. The question we asked ourselves was: what is the best strategy to coordinate the appropriate deployment of techniques to help solve the diverse range of taxonomic and diagnostic problems that are demanding attention within the area of plant protection?

Progress in identification and diagnostics is frequently hampered by taxonomic problems These problems may be as clear cut as an absence of alpha taxonomy on a particular group . At the other end of the scale a problem may go much deeper to recognising limits of sexual species when anatomical characters fail to resolve an identification question. Studies have shown that species defined solely on structural characters may not represent the true limits of sexual species. Differences between such species may be reflected in, for example, behavioural characters. No biological principle demands that species be structurally different from one another yet all too often we assume that if populations of morphospecies do not show anatomical differences they must represent single species. Consequently we fall into the trap of making wrong inferences about such populations. In reality, species may differ only in relation to their behaviour or physiology.

We are planning an integrated approach to diagnostics and entomological research in the CRCTPP. Such an approach will require a coordinating body that assesses problems and then targets diagnostic techniques appropriate for particular problems. This approach is superior to one that leaves the decision about solving a diagnostic problem up to an individual who may have some expertise with the group in question but that expertise may not be appropriate to the solution. Each diagnostician has particular expertise and tends to perceive solutions on the basis of that expertise.
An old saying perhaps best encapsulates this situation:

"When you have a hammer, everything looks like a nail"

Clearly a single approach to a range of taxonomic questions is not appropriate. Not all problems can be solved with morphological taxonomy just as they cannot all be solved with molecular techniques. If we coordinate entomological studies in the CRCTPP the best procedure for solving each diagnostic problem can be assessed and the specialist with appropriate skills can be given the task of finding a solution. In this way we believe we can go a long way towards avoiding 'hammer and nail' situations. We propose a **Diagnostic Ladder** approach. Each step of the ladder represents a different strategy or technique.

DIAGNOSTIC LADDER

STEP	INFORMATION REQUIRED	INSECT EXAMPLE	STRATEGIC ACTION	OUTPUT
4 ↑	Diagnostic tools	✣ PNG mosquitoes ✣ *Helicoverpa* pests	✣ collaborative research grant applications	✣ Lucid keys ✣ Molecular diagnostics
3 ↑	Diagnostic Screening - for races, biotypes, sibling species	✣ *Amrasca devastatus* (Javan vs Australian populations)	✣ literature search ✣ identify most appropriate methodology for species of interest - pheromones, volatiles, cuticular hydrocarbons, sound analysis, allozymes, microsatellites ✣ collaborative research grant applications	✣ Accurate risk assessment ✣ Knowledge to underpin development of molecular diagnostics (Step 4)
2 ↑	Basic taxonomy - species level and below	✣ *Perkinsiella* spp. in PNG	✣ trace international expertise ✣ literature search - available keys, descriptions, named specimens, ecological information ✣ collaborative research grant applications	✣ Comprehensive keys ✣ Lucid keys
1 ↑	Basic taxonomy – species, genera, families – revisions of taxonomic groups	✣ Delphacid bugs ✣ Spider mites	✣ trace international expertise ✣ literature search - available keys, descriptions, named specimens, ecological information ✣ collaborative research grant applications	

Suppose we suspect that we have 'good' sexual species and they have no diagnostic anatomical features. Diagnostic problems of this nature cannot be solved at Steps 1 or 2 of the Diagnostic Ladder but at Step 3. For example, specific mate recognition systems, such as courtship and mating songs, may be discovered. Once these are known specific diagnostic tools can be employed to produce the desired outputs (Step 4).

The solution to diagnostic problems could start at any of the four steps and an integrated approach will allow determination of the step at which the work should start and the most appropriate person to undertake the research.

APEC WORKSHOP - CONTAINMENT OF TRANSBORDER MOVEMENT OF PLANT PESTS, BRISBANE, JULY 2001

NETWORKING RESEARCH PROGRAMS FOR THE DIAGNOSIS OF PESTS AND DISEASES IN PLANTS AND ANIMALS IN VICTORIA

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Globalisation has exposed consumers worldwide to greater choice in food and agricultural products, and has led to an increased demand for higher standards in food quality and safety. As a result trading partners are raising the technical standards of imports – in terms of sanitary standards, food safety and labelling, and chemical and environmental standards. Export products must meet trading partners' and consumers' requirements. It is also critical that these products are free from pests and diseases that could pose a threat to our partner's agricultural production.

Victoria has built up a reputation as a producer of clean and safe food, backed by the Department of Natural Resources and Environment's (DNRE) world-leading capability in the diagnosis and effective management of pest and disease outbreaks. This capability is now being further enhanced through a project which has the support of the Victorian Government's Science, Technology and Innovation (STI) initiative. The project aims to:

- *provide methods to rapidly* demonstrate that products meet the pest and disease regulations of importing countries;
- develop a capability for fast, accurate diagnosis of exotic pests and diseases that may threaten Victoria's major food exports; and
- improve the preparedness for, and the management of, incursions of exotic pests and pathogens.

Plant industries are poorly prepared to deal with outbreaks of exotic pests and diseases, by comparison animal industries are relatively well prepared. This projects enables resources from across the DNRE to join together in a research network to capture the best diagnostic capabilities available worldwide.

Diagnostic probes for exotic and emergency plant and animal diseases

DNRE's laboratories diagnose many exotic and emergency diseases but diagnostic science is constrained by the lack of "hands on" experience in working with organisms that are exotic to Australia. Rapid response times are critical in emergency situations to give quarantine authorities the best chance of eradicating introduced pests or diseases.

The STI-supported project is developing diagnostic technologies to detect key exotic and emergency diseases that could threaten the viability of Victoria's plant and animal industries. This is being achieved through collaboration with overseas centres of excellence and by the use of molecular tests that avoid the problem of on shore work with live cultures of high risk organisms. These diagnostic technologies will then be integrated into contingency plans to improve preparedness in dealing with incursions of exotic pests and diseases.

For the horticulture industry, the project is targeting Pierce's Disease of grapevine, and *Plum pox virus* (PPV) of stone fruit. PPV has potential to dramatically reduce quality and yield of stone fruit. In the US and Europe, it has been recognised as the most significant threat to the viability of the stone fruit growers. The exotic Pierce's Disease of grapevine is of particular concern to the wine industry. It could have a dramatic effect on wine grape production in riparian environments such as the Murray Valley. Experience in California shows severe losses in southern counties where entire vineyards have been destroyed by this disease. Over the last three years costs of $46M US have been incurred in managing Pierce's Disease in the Napa Valley in Northern California.

For the livestock industry, the project is initially focusing on developing probes for the rapid diagnosis of anthrax and 'molecular typing' tests to distinguish between the virus that causes Newcastle disease in poultry and other closely related native non-pathogenic viruses.

The NRE project is also applying gene technologies to develop molecular probes for the rapid and early detection of diseases that threaten important grain crops. Initial work is focussing on anthracnose of lentils and stripe rust of barley.

Molecular techniques for disease-resistance breeding
The recent devastation of Victoria's chickpea industry by an exotic disease, chickpea blight, caused by *Ascochyta rabiia*, illustrates the consequence of a poor level of preparedness to deal with exotic pests and diseases.

One of the most effective strategies for preparedness is to develop pre-emptive resistance breeding programs. However, for cases where the disease organism is not present in Australia, this strategy is not possible with traditional breeding methods.

The project team is therefore looking at DNA based markers that would confirm that breeding lines carry resistance to exotic pests or pathogens.

Meeting world trade requirements
Under recently revised arrangements of the World Trade Organisation, it is no longer acceptable for trading countries to erect trade barriers on sanitary grounds. Member countries of the WTO are required to provide evidence that the specific organisms to be quarantined and excluded are confirmed as exotic and will have significant economic or environmental impact.

To address these requirements, the project team is developing a system that will provide a quick and reliable method of checking which pests and diseases are present in Victoria and Australia and which ones are exotic. This involves validating records and updating databases of pests and diseases that have occurred in Australia, and making this information available on an Internet website. This will enable quarantine managers to provide immediate responses to questions from trading partners about the pest or disease status of a commodity grown in Australia. These details are frequently required before trade can commence. The project initially focuses on pests and diseases in stone fruit, pome fruit and potatoes, which are all valuable export industries for Victoria.

The project team has re-examined and validated existing reference collections of endemic plant pests and diseases for these crops, to ensure that spurious and outdated records do not compromise trade. The team is also incorporating plant viruses, nematodes and bacteria into the existing databases for plant pathogenic fungi and insects. Non viable voucher specimens of exotic pests and pathogens from overseas collections are also being obtained as a first step towards the development of a diagnostic capability.

Project Outcomes

The project has helped establish a formidable Victorian capability in diagnosing and managing outbreaks of pests and diseases that could threaten the livelihoods of Australia's food and agriculture enterprises and businesses. The diagnostic capability has already been accessed by AQIS and successfully diagnosed PPV, and identified it to strain in illegally imported plum budwood, in just 36 hours. The diagnostic protocols for Pierce's disease have also been used by AQIS again in illegally imported grapevine material and in post entry quarantine. Currently a test developed by the NRE team is being used to help contain an outbreak of *Potato spindle tuber viroid* in Western Australia. Hopefully this is just the beginning of a network of diagnostic capabilities around australia.

APEC WORKSHOP – CONTAINMENT OF TRANSBODER MOVEMENT OF PLANT PESTS

DIAGNOSTIC DELIVERY PLATFORMS

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Invertebrate pests, plant pathogenic bacteria, fungi, nematodes, viruses and virus like organisms all take their toll on agriculture and forest industries. Many countries have developed relatively sophisticated pest and disease management programs, which effectively contain losses due to endemic organisms. However, the introduction of exotic pests or pathogens presents new challenges to government agencies and industry organisations. The difficulty is recognition of the new threat, understanding its biology and epidemiology in the "new" environment and determining how it can be effectively controlled and contained.

Diagnostic science is a fundamental tool for effective management of plant pests and diseases. If the causal agent is not correctly identified then frequently recommendations for control and containment may be inappropriate and economic loss can occur. Diagnostic protocols are fundamental for survey and monitoring activities and are a key to understanding the epidemiology of organisms from which knowledge based pest management strategies can be developed. These might include the use of chemicals, resistant germplasm, hygiene and other management practices including biological treatments.

Primary Diagnostic Platforms

The two fundamental platforms on which diagnostic science are based are a sound understanding of both the diversity of the target organisms, and closely related species, and the biology of the organism within the host and the environment. Essential requirements are:

- taxonomic resources which include reference collections of authenticated specimens of plant pests and pathogens and associated studies on morphological and molecular diversity. and
- secondly a diagnostic capability, which uses the latest diagnostic technologies to detect and validate pest microorganisms.

Reference collections of plant pests and pathogens underpin diagnostic services and are used to verify diagnosis. They are usually accumulated over time and comprise representative samples of organisms, which are normally present in an area or country. To be effective, it is essential that these specimens be identified and validated by experienced taxonomic specialists. In effect the collections can, if properly managed and resourced, represent a reasonably accurate picture of what's in a country and by definition what's not. Thus they form the basis for quarantine management decisions and risk analysis for import and export under WTO guidelines.

Diagnostic methods and capabilities – a basic understanding of plant pathology and entomology, of common plant pest and disease problems and of the causal organisms and their biology is fundamental for diagnostic science. It is analogous to the situation of a General Practitioner in medicine. The plant diagnostician has an overall knowledge of how plants react to stresses that may or may not be caused by pests or diseases. Tools required for the job are field experience in the recognition of symptoms and damage, a good hand lens, microscope, basic culturing facilities and simple laboratory.
At this level many of the common pests and diseases with unique symptoms and morphological characters can be successfully diagnosed. However in situations where symptoms are not characteristic, or are unusual, and where the target organism is systemic and not easily visualised further more specialised diagnostic expertise and tests are required.

Secondary Diagnostic Platforms

More specialist diagnostic protocols are increasingly used in the characterisation of organisms that cannot be easily distinguished on morphology or which are not easily visualised by culturing and microscopy. The feature of these technologies is that they target a particular feature, which is unique to the organism's metabolism or genome. Tests can be grouped into direct and indirect types. Direct tests

usually involve recognition of the morphology of the organism on selective media, whereas indirect tests detect the presence of components of the pathogen.
The results need careful interpretation to ensure that the test is not compromised by related organisms either as contaminants or through cross reactions. Because of this complexity, diagnoses are usually made by analysing and interpreting the results from a series rather than from individual tests.
In plant protection enhanced capabilities for diagnosis depend on critical mass in entomology, bacteriology, mycology, nematology and virology. Each discipline is increasingly developing a complex suite of diagnostic tests which cover morphology, culturing, serology, biochemistry, and molecular analysis. With these tools it is possible to achieve more accurate and timely characterisation of organisms and even identify strains and pathovars.

Direct tests

Morphology:
Is recognised as a powerful tool. It needs an experienced eye to recognise the morphological features which differentiate an organism from its close relatives. This is used in entomology, mycology and nematology but has more limited application in bacteriology and virology. An essential requirement for morphological analysis is comparison with voucher specimens, and if these are not available the task can be difficult.

Selective media/biochemical tests:
This is frequently used in conjunction with morphological analysis where organisms, usually bacteria and fungi, are grown on media which is selective for their growth but which suppresses the growth of related organisms which can confuse the diagnosis The skill is in recognising and differentiating the colony characteristics of the target organism from others which inevitably grow on the media. Frequently PCR and other rapid tests are applied to the isolated colonies to confirm their identity.

Pathogenicity:
Demonstration of Koch's postulates is the absolute confirmation that the isolated organism is a pathogen. All other tests focus on the characterisation process and they may isolate non pathogenic species. Pathogenicity testing usually resolves this The difficulty is that the process can be protracted and may require several weeks before a result is available. Forward planning is essential to ensure that the plants and cultures to be tested are at the right stages of growth to ensure infection and symptom expression. When dealing with exotics this will require that the tests are conducted in a secure facility to avoid the risk of escapes.

Note: a problem with direct tests is that they should incorporate positive controls and securing approvals for this type of work can be difficult if containment facilities are unavailable

Indirect Tests
Note: can be done without live positive controls

Serology,
Is fast, cheap, robust, can be mechanised, requires little training, suitable for large numbers of samples, can be very sensitive and does not require a living positive control. Serology detects the presence of specific proteins and has been developed for application in virology and bacteriology. and is also being extended into other areas.
It requires antisera of known specificity, which is a finite resource. Antisera can be too specific (eg for viruses) or not specific enough (eg for bacteria). Serology cannot be used for detecting viroids, because they don't elicit an immune response in animals. False positives and negatives are a real risk and interpreting results requires experience.

PCR/ Sequencing
PCR is fast, sensitive, specific and also does not need living positive control. It can be designed for generic or specific application to identify genera, species or strains and is a very flexible technology.
PCR can give false positives either because it is not specific enough or it can be too specific. This is partly because the tests frequently are developed with a relatively small part of the genome of target organisms. PCR requires highly skilled staff and relatively sophisticated lab setups. Recent research in our laboratory indicates that validation is critical when dealing with detection of exotic

organisms. Experience shows that in the Australian environment unexpected false positives occur which can lead to errors in quarantine management.
DNA sequencing is an "extension" of the PCR protocol which is increasingly being used on PCR products and can be extremely valuable in confirming the identity of the target organisms.

How does it work
As mentioned earlier correct diagnosis is fundamental to effective quarantine, pest and disease management the challenge is to provide timely and accurate diagnostic services for growers and quarantine managers.

Infrastructure is a critical part of diagnostic laboratory, which provides information services to growers and quarantine managers. The type and level of infrastructure obviously depends on the size of the operation, however essential components are considered to be:- a front desk for servicing enquiries, databases to record sample details and results, access to reference collections for authentication, dirty and clean laboratories, reference literature and books and specialist equipment

Specialist knowledge discipline specialists engaged in diagnostic science need to have a comprehensive understanding of the range of organisms and their symptoms which are normally encountered in a region on particular commodities. The corollary is the requirement to recognise the unusual, which may be an exotic organism Each discipline, be it mycology, or virology, also requires a capability to conduct a range of contemporary tests and also those intangible detective skills which enable the scientist to select tests and interpret the results.

Communication is vital for an effective diagnostic service The ultimate aim is to integrate the knowledge of the specialists to provide a collective capability which, because of critical mass, is far greater than the knowledge of the individual practitioner. Specialists can be notoriously "blinkered" and blindly look for the answer from their discipline The virologist may miss a symptom, which is obvious to the bacteriologist. The dilemma of bias can only be overcome by an effective consultation process, which links the collective knowledge of diagnosticians and discipline specialists when working with difficult samples.

Time frames to achieve a diagnosis are particularly important in quarantine management and for crops of high cash value. The quarantine manager needs a decision as soon as possible to implement containment strategies and capture opportunities for eradication. The grower needs accurate information on control treatments to minimise losses and realise their investment in the crop. It is therefore very important that diagnosticians impose time lines on their activities, which recognise when sufficient information is available for pest/disease management decisions. Frequently there is a requirement for guaranteed turn around times for particular tests.

The peculiarities of quarantine diagnostics in Australia
It is a salutary experience for diagnosticians involved in the identification of pests and diseases for quarantine management to reflect on the significance of their work. The results from diagnostic tests can significantly affect livelihoods.

The importance of the role is recognised by quarantine agencies, but the dilemma is that Australian diagnostic scientists are not well prepared to isolate and confidently identify many of the insects, bacteria, fungi, nematodes and viruses that are exotic to Australia. This is primarily because of their unfamiliarity with the symptoms of exotic pests and diseases and of the techniques required to isolate the causal organisms. Under current arrangements there is a veto on the importation of live cultures of exotic pests and pathogens into containment facilities in Australia for on-shore training of diagnostic scientists, quarantine inspectors and appropriate field staff and for use as positive controls in the event of an outbreak.

Another difficulty is deciding which of the hundreds of exotic pests and diseases should be the focus for enhancing diagnostic competencies. It is not possible in the short term to develop competencies for everything.

Diagnosticians usually become involved through samples submitted to the laboratory or through advice from the field advisors and growers who report the occurrence of an unusual symptom or disorder not seen before. Their usual response is to search the scientific literature and the web, and send email queries to overseas experts for additional information. These sources also give guidance on the preferred diagnostic tests, which should be used to isolate and identify the causal organism.

For some organisms, which have unique morphological characteristics, identification is a relatively simple task. However for other more cryptic plant pests and diseases, diagnosis is more complex and requires specific sampling strategies and tests to absolutely confirm the identity of the organism

Experience has shown this to be the case with some bacteria, fungi, viruses and insects such as fruit flies, and completion of the full suite of tests can take up to two weeks and even longer if samples are sent overseas.

This presents a particular dilemma for quarantine management decisions, because in the heat of an emergency, diagnostic scientists can be under significant pressure to confirm the outbreak Results from diagnostic tests are required as quickly as possible to implement quarantine action and prevent further spread – two weeks is usually too long to wait. But the diagnostician's concern is to avoid making a hasty decision only to discover later that it was a "false alarm". This is a real problem, which has confronted quarantine agencies in at least three recent incursions involving an exotic fruit fly, a bacterium, a nematode and a plant virus. Each case exposed the difficulty of deciding when information from tests is sufficient to establish quarantine action.

A second, often unanticipated, problem concerns the specificity of the tests. In other words it is important to have confidence that results are not confused by cross-reaction with related organisms, which can lead to errors in quarantine management. Validation of tests is critical.

Australian diagnostic protocols for exotic pests and diseases are usually based on tests, which have been developed in overseas laboratories where the pest or disease is endemic and positive results are usually interpreted to mean the organism is present in the sample. In Australia the situation is somewhat different because tests are usually applied to samples from an environment where presence of the organism is not anticipated. This is especially important for the so called indirect tests such as ELISA and PCR. Positive results need to be interpreted with care because of the risk of cross-reactions, some of which may be caused by our unique Australian microflora, which is not present in other countries. Recent evaluation of diagnostic protocols for *Erwinia amylovora, Xylella fastidiosa* and *Plum pox virus* has shown that false positives can occur, particularly with PCR tests, which means that PCR alone should not be used as the basis for quarantine action. Similar problems can occur with selective media and ELISA tests
The diagnostician needs to be aware of such pitfalls that can only be identified by validation of diagnostic protocols on samples collected in the Australian environment. Familiarity with the strengths and weaknesses of the tests enables improved interpretation of results for quarantine managers.

APEC Workshop to Contain Transborder Movement of Plant Pests: Diagnostics

COMMERCIAL DELIVERY OF ROOT PATHOGEN TESTING: A TOOL FOR DISEASE MANAGEMENT

Felice Driver
C-Qentec Diagnostics Pty Ltd

The Role of C-Qentec in Commercial Diagnostic Test Delivery:

C-Qentec Diagnostics is a newly formed Australian subsidiary of Aventis CropScience (ACS). Aventis is a leading life sciences company with 95,000 employees based in 120 countries and was formed in December 1999 from the merger of Hoechst and Rhône-Poulenc.

C-Qentec was established in January 2000 with the primary focus of developing and marketing DNA and protein based diagnostic tools for agriculture. PreDicta™ B, a predictive PCR based DNA diagnostic tool for broadacre farmers, is the first product to be commercially marketed and distributed by C-Qentec. PreDicta B assesses the potential risk of a range of important soil borne diseases prior to planting Combined with a comprehensive decision support package, PreDicta B allows growers to implement a range of management decisions to maximise cropping potential.

The other product recently launched by the company is WheatRite ™ an immunoassay for weather damage in wheat. This is a rapid on-farm test that can be used to assess pre-harvest sprouting and is particularly useful for farmers in wetter regions of Australia.

Ongoing research and development is a key to the long-term success of C-Qentec with new tests in development for a range of crops including cotton, pulses, ornamentals and potatoes. These tests will be a result of ongoing collaboration with a wide range of research partners including SARDI, CSIRO, CRCTPP, AgVic and QDPI.

Aventis CropScience has been developing its business in new knowledge based precision farming tools: predictive software to help farmers use the right product at the right time; diagnostics to help farmers identify pests and diseases with a high degree of accuracy; and remote sensing to locate infield variation in order to adapt product application. These services are designed to help farmers minimise the environmental impact of inputs and improve profits.

Until recently support services have been freely supplied to rural industries in many countries through subsidised company schemes or government agencies. Most countries are experiencing a loss of trained pathologists, and a contraction of those government sponsored services. A conscious decision is being made by companies to invest and capture the value from such knowledge based services.

Development of Diagnostic Tools and the Research Community:

The involvement of private companies into the field of diagnostics and disease management has created a paradigm shift in the culture, effectiveness and way research findings are delivered to the farming industry. The technology was developed by CSIRO and SARDI to assess soils for arrange of nematode and fungal pathogens. The primary steps in this development have been:

- specific DNA probes
- extraction of DNA from soil
- quantitative assays
- calibration of DNA tests to existing quantitative methods where possible
- assessment of predictive value of DNA test against field trial data
- development of risk categories against economic thresholds and yield loss data
- development of decision support strategies to manage disease impact
- training of extension workers to liase with farmers to interpret test results and implement management options.

Funding has been received through many public organisations as well as seed funds from Rhône-Poulenc to support this development, and conflict can arise over the definition of public good research for private benefit. The commercialisation of the research has provided a conduit for 15 years of research into disease management as well as an effective outlet for further developments.

The service was first delivered as the Root Disease Testing Service from 1998-99 by SARDI Diagnostics under license to Rhône-Poulenc. A delivery network was created through fertiliser companies and agro-chemical resellers in which agronomists were trained by SARDI in a one day course designed to teach the fundamentals of root disease management, interpretation of test results guide farmers through a range of decision support options. The technology was licensed to Aventis CropScience in November 2000 and delivered through C-Qentec Diagnostics.

Commercial Tests:

Currently the PreDicta™ B package of tests for broad acre cereals delivers tests for Take All (*Gaumannomyces graminis* var. *tritici* and *G.g.* var. *avenae*), Rhizoctonia Bare Patch *(Rhizoctonia solani*), Root Lesion Nematode (*Pratylenchus thornei*, and *P. neglectus*), Cereal Cyst Nematode (*Heterodera avenae*) and Black Spot of field peas (*Mycosphaerella pinodes*). Tests under development are aimed at including all major diseases of cereals and rotation crops, such as Crown Rot (*Fusarium pseudograminearum* and *F. culmorum*) and Blackleg (*Leptosphaeria* maculans) and Sclerotinia (*Sclerotinia sclerotiorum*) of canola.

Other R&D projects linked with different research partners at CRC-TPP and AgVic are directed to the development of tests for Fusarium Wilt (*Fusarium oxysporum* f.sp. *vasinfectum*) of cotton, Phytophthora diseases in the nursery industry, forestry and for pulses, Root Knot Nematode (Meliodogyne) and Fusarium Wilt of tomatoes (*Fusarium lycopersici*), powdery scab (*Spongospora subterranea*), and black scurf (*Rhizocontia solani*) in potatoes for the horticulture industry.

Criteria for Delivering Diagnostic Tests into a Commercial Platform

The initial planning phase for any new project should identify *all* the necessary participants that will collaborate in bringing a diagnostic test to fruition, and then successfully to the end user, whether this is in the commercial arena, for research purposes or quarantine use. Collaborators should try to avoid duplication of tasks and "re-inventing the wheel" and allow participants to each do what they do well. In the case of research providers this may mean learning to let go of their phase of research and not continue to "retain ownership" of the project once licenses are granted and commercial decisions are being made. This does not mean relinquishing involvement, or a lack of consultation at this stage of the process.

Funding issues also need to be addressed from the outset to ensure all parts of the process are adequately resourced. In general costs and time scales involved in calibrating a DNA based test against other quantitative methods such as field trials and bioassay data to assess disease severity and potential yield loss data, and then assigning risk categories can place far greater demands on resources than the initial development of the molecular test This is not meant to belittle the difficulties that may be encountered in devising strategies to develop some molecular tests.

In deciding to develop a commercial test careful consideration needs to be given to the epidemiology of the disease, recognition of symptoms, appropriate sampling regimes tailored to the type of organism and its distribution. DNA extraction protocols for tissues and environmental samples, sensitivity of detection and the desirability of a quantitative or pass/fail test format Consideration of a phylogenetic and bio-informatics approach to the specificity of DNA probes and potential for cross reaction when developing PCR based tests which can otherwise lead to errors in test results, especially significant in quarantine management. Essential to commercial viability is the development of compatible tests formats that utilise a single, or restricted technology platform. This is paramount for incorporating automation, and high throughput capacity, it streamlines controls and standards and quality assurance. The capital costs of equipment and laboratory infrastructure also impacts on delivery and the technology of choice. Awareness of the pitfalls, strengths and weaknesses in building tests is as essential in the development of quality assurance programs in the process line as it is in interpreting results.

The provision of quarantine diagnostic services to manage biosecurity, establish area freedom and participate in eradication programs is often complicated by low volume of sampling and throughput until an incursion or outbreak of disease occurs. Development of tests and delivery platforms may be more fragmented, labour intensive with a more "low tech" approach. Where possible tests should be configured to be adaptable to a high throughput automated system when necessary. Commercial, quarantine and research processing of samples are not mutually exclusive activities.

Tests that are of paramount importance for biosecurity or research purposes do not necessarily determine commercial viability. Here the yard stick is the likelihood of technology uptake and resultant high throughput of samples which is influenced in turn by pricing structure, acreage planted, value of the crop or commodity in the market place, recommend sampling rates, comprehensiveness of disease testing package and providing solutions and management options which are tailored to local needs.

End User:

What determines whether a farmer will adopt a new technology? Basically it is driven by two questions. Does it work? Is it profitable? Value perception or return on investment is the bottom line. It is irrelevant how good the scientific research and technology may be if growers do not perceive value in the tests on a re-current basis. The technology will sit on the shelf unless it is affordable or there is a mandatory element to testing or subsidises for use of the testing service.

Value can be perceived and supplied in several ways. Cost savings, market access and potential yield increases associated with risk or disease management:

- better management of no-till agriculture
- potentially lower or better targeted inputs such as fungicides, herbicides and fertiliser
- efficient land use
- choice of break crops and alterant varieties as appropriate
- trade which flows from pest free status
- positioning in the market of suppliers of certified disease free materials

Conclusions:

The delivery of services whether they are commercial, for quarantine or market protection purposes or research use requires essential partnering and collaboration between participants. It requires shared risk and huge investment in R&D at all levels. The commercial need of companies for exclusivity is complicated by the need for inputs from public R&D corporations and government scientific institutions that are often unwilling to fund developmental research that they perceive as benefiting a commercial partner. Clearly, there needs to be a financial return to contributing organisations and a clear definition between private and public good research. Acknowledgement and recognition by research institutes and corporations of the role and multimillion dollar investment made by the commercial partner to deliver and market diagnostic services needs to be considered as much a valid input as R&D when negotiating licensing fees, royalties.

APEC Worksop to Contain Movement of Plant Pests: Diagnostics

Glenn Graham

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Introduction

The Centre for Identification and Diagnostics is a collaborative Centre involving three research organisations, The University of Queensland, The Queensland Department of Primary Industries and Natural Resources and Mining. The Centre is located at the St. Lucia campus of The University of Queensland within the School of Life Sciences

The establishment of the Centre for Identification and Diagnostics of Weeds and Insects (CID) provided The University of Queensland, The Queensland Department of Primary Industries and Natural Resources and Mining with a unique skill base in techniques for molecular genetics studies of weeds and insects CID conducts specific research using molecular techniques to investigate specific issues in integrated pest management, species taxonomic relationships for identification and develops these findings into diagnostic tools for research and field based decision support. In addition to this CID's research outcomes have contributed to the basic understanding of species ecology and behaviour This has enhanced existing activities and research in weed and insect control in the collaborating participants. Furthermore CID will continue to meet the demands of other departments and scientific organisations for this kind of understanding and interpretive knowledge.

St. Lucia is a major centre for molecular research in Australia and will continue to be so in the long-term future CID has benefited from its location on the University campus and is well placed at the centre of the Molecular Biosciences Precinct. This benefit flows to the School of Life Sciences, QDPI and NR&M through CID's critical linkages to other scientific groups and organisations.

Objectives

The goal of the Centre for Identification and Diagnostics is to provide research and operational tools for use in development and optimisation of integrated pest management strategies, identification tools for weed and insect species and to provide a research environment in which to train students and scientists in molecular biology. This training has provided a valuable resource of scientists capable of undertaking research with a molecular focus in weeds and insects. The CID has and will continue to make a positive contribution to develop molecular technologies for collection of information on genetics of weed and insect pest species and seeks to further expand its technology base to keep pace with this rapidly changing area of science. These technologies include DNA-based diagnosis of biocontrol agent activity and efficacy analysis of biopesticides. In addition, analysis of biogeographical origins of weed and insects species by molecular means provides information for developing strategies of control and management of these species.

The key objectives are:

- to provide a positive contribution to the development of molecular tools for collection of information on the genetics of plant and insect species.
- to educate students and scientists through short courses and by providing high quality, laboratory-based training of post-graduate scholars and scientists
- to identify strategic opportunities to expand its core business and client base to further enhance the goals and objectives of its participant organisations
- to provide a nexus for its participant organisations in molecular genetic studies of weeds and insects
- to seek means to maintain and update its technical capacity by strategic investment in personnel and physical resources
- to maintain its focus on delivering high quality research outcomes to its participant organisations and clients

Research Activities

CID currently is undertaking research in variety of insect species Due to the varied nature of it's research program some of these insect species are pests, while others are beneficials used to control pestiferous insects and weeds With the focus of this workshop presentation on insects, included are some of the research projects we are involved with.

Perkinsiella saccharicida

Perkinsiella is the vector for the transmission of Fiji disease, a virus that affects sugar cane production. This disease is a threat to sugar production nationally and internationally. In Australia cultivars of sugar cane grown are moderately susceptible to this disease. There is however insufficient understanding of the virus and virus/vector interactions. The purpose of our research is to clarify the species status of *Perkinsiella* and examine its population dynamics. In addition, the molecular phylogenetic tools we are developing will enable us to identify, if any, population sub-structure in the Australian occurrences. This research is funded through the CRC for Tropical Plant Protection, Brisbane

Pyralids (stem borers)

Stem borers have been identified as an important pest-incursion threat faced by the Australian sugar industry. Recent BRS-AFFA workshops identified the need for Pest Risk analysis, development of incursion plans, implementation of monitoring and surveillance system, identification of pathways for incursion and development of identification and diagnostics methods for a range pests including stem borers. This project seeks to develop accurate identification methods for stem borer larvae. Using molecular phylogenetics, CID is developing DNA based diagnostics for a wide range of exotic and endemic species of stem borer. This will be achieved by using collections of easily identifiable adults as voucher specimens for analysis and using the subsequent diagnostics to identify the larvae of these species which prove to be problematic by morphological means. This research is funded by the SRDC and BSES with linkages to QDPI, CSIRO, ACIAR and NOAPH.

Helicoverpa spp.

Helicoverpa armigera is a polyphagous insect costing the Australian cotton, grains and horticulture industries approximately $900 million dollars per year in control and lost production. *Helicoverpa armigera* is a highly adaptive species, developing resistance quickly, and to almost all known chemical control agents. This research program is designed to establish the proportions of migration and local recruitment in the four major cropping regions of eastern Australia. The tracking of resistance is important and this research has developed a strategy for assessing migration and local recruitment. The research program has developed a molecular means of tracking migrant origins, making it a powerful tool for identification of resistance build up and movement These tools can be equally applied to the tracking of origins of insect incursions by appropriate 'over the horizon' collections and monitoring. This research is funded jointly by GRDC, CRDC and The University of Queensland.

Dacinae Tephritids

This research involves the construction of a phylogenetic relationship between species of two genera, *Dacus* and *Bactrocera* A comparison of the results of these studies with the conventional classification of the Dacinae will be undertaken. Nodes that are both strongly supported in the analyses and conflict with the current classification will be subject to further scrutiny. The classification may require modification after critical re-evaluation of character support. This will serve to strengthen the utility of conventional taxonomy A phylogenetic reconstruction can be used as a tool to map specific ecological and physiological data. From these analysis inferences about the evolution of such things as lure response and host preference can be made to underpin studies into the diverse biology of these groups of species This research is funded by ARC and is undertaken in collaboration with Griffith University.

Microplitis demolitor and *Trichogramma spp.*

Both of these species are parasitic wasps of Heliothis. These species have been under investigation to assess their utility as bio-control agents. CID has developed DNA based diagnostics for these species as research tools to investigate their prevalence and effectiveness in control Heliothis in the Australian agro-ecosystem. This research is undertaken in collaboration with the Farming Systems Institute of the QDPI. The diagnostic allows an accurate identification of the respective parasites, which are difficult to identify by visual means. This work is funded by QDPI, The University of Queensland and GRDC.

CID's Diagnostic Capability

CID has a modern well resourced facility at The University of Queensland. This facility is designed to provide basic through to applied research outcomes for it's clients. The Centre is well placed in this respect with strong applied linkages to a wide range of agricultural industries and combines this with the teaching and training strengths of The University of Queensland. CID has a commercial group, undertaking technology transfer and exploitation of intellectual property, bring the basic research outputs to users of these technologies.

The diagnostic capability is flexible in its delivery and constructs diagnostics specifically tailored to each individual requirement. Many diagnostics are not required in a commercial sense but are developed as research tools delivering secondary information to problems of insect and weed control and incursion. However commercial assays are delivered as a full cost recovery system.

In addition CID provides training and education to students and scientists in molecular diagnostics, allowing the adequate transfer of knowledge and skills to organisations that use them in their domestic research and control programs.

It is expected that the future of CID's research program will be to investigate the emerging Genomics and Proteomics technologies These new technologies allow molecular biologists to identify the specific regions of an organisms genome that confers traits of interest. The current approach to diagnostics is limited by the amount of genetic data that can be collected and deployed as a diagnostic. Genetic diversity of any organism is constantly changing and so requires an evolving technology to cope with these changes Ultimately it will be possible to compare whole genomes or proteomes of individuals and deploy these as standard diagnostics, allowing for recent and subtle changes to be seen and considered in our quest for absolute diagnostic information.

Diagnostics of Quarantine bacterial pathogens: "Know your enemy"

Dr Mark Fegan, CRCTPP, Brisbane, Australia

The Importance of Taxonomy

Classification, nomenclature and identification of plant pathogenic bacteria are important issues for quarantine. It is of paramount importance that the names (nomenclature) of plant pathogenic bacteria are unmistakable to both the scientists involved in identifying them and the legislators trying to regulate against the importation of the pathogens on contaminated material. Inappropriate naming of organisms leads to confusion in the literature, for example pathogen distribution maps, and hence problems in legislation for plant quarantine. Confusions in nomenclature can limit the export of products or conversely lead to the introduction of an unwanted pathogen.

In recent years, the taxonomy of plant pathogenic bacteria has been extensively revised. Unless the plant pathologist is aware of these changes confusion will follow. A list of validly named bacterial plant pathogens, from the International Society for Plant Pathology (ISPP), containing the names of all plant pathogenic bacteria which have been validly published in terms of the International Code of Nomenclature of Bacteria, and the Standards for naming Pathovars is available at – http://www.isppweb.org/nppb.htm

To accurately identify a bacterial pathogen and to develop diagnostic tests to identify the presence of a pathogen it is important to understand the taxonomy of the pathogen in question. This understanding may be at the level of the species or, as is commonly the case for plant pathogenic bacteria, at the infrasubspecific level.

The importance of understanding the diversity of bacterial pathogens for the development of infrasubspecific diagnostic tests: the example of *Ralstonia* (*Pseudomonas*) *solanacearum*:

R. solanacearum causes bacterial wilt of many important crops worldwide. The bacterium is a quarantine organism in many tropical and temperate countries of the world. Generally, quarantine inspection for *R. solanacearum* consists of visual inspection of crops for disease symptoms. However, as the bacterium can latently infect such crops as potato, ginger and banana producing no visual symptoms visual inspection of crops is not always effective. Bacterial wilt of potatoes and bananas has been spread both locally and internationally on latently infected plant material.

Ralstonia (*Pseudomonas*) *solanacearum* is a very diverse and complex species with a host range encompassing over 50 plant species. This bacterium has been subdivided into races based upon host range (not true races), biovars

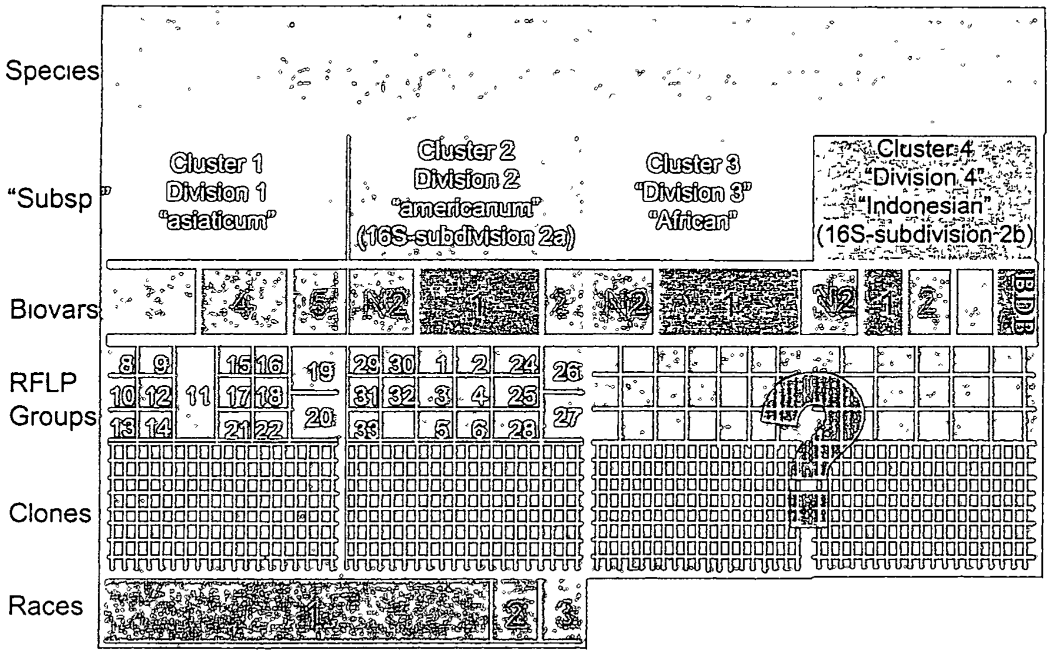

Figure 1. Known diversity of *R. solanacearum* and closely related bacteria. Adapted from Gillings and Fahy, 1993.

based upon oxidation of sugars and sugar alcohols and multilocus groups based upon restriction fragment length polymorphisms (RFLPs).

Recent research in our laboratory and others has demonstrated that *R. solanacearum* can be subdivided into four genetic groups (Figure 1).

Based upon knowledge of the phenotypic, pathogenic and genetic diversity of *R. solanacearum* a hierarchical series of PCR tests to detect different groups of *R. solanacearum* of quarantine interest have been developed. Tests for the identification of which cluster an isolate belongs to and for the identification of *R. solanacearum* belonging to races 2 and 3 (Figure 1) will be discussed.