FRUIT FLY IN MALAYSIA AND THAILAND 1985–1993

ACIAR Projects 8343 and 8919

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▶▶▶▶ ACIAR is concerned that the products of its research are adopted by farmers, policy-makers, quarantine officials and others whom its research is designed to help.

▶▶▶▶ In order to monitor the effects of its projects, ACIAR commissions assessments of selected projects, conducted by people independent of ACIAR. This series reports the results of these independent studies.

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Contents

1. Summary

Fruit flies are a serious economic pest affecting horticultural production world-wide. Increasing coordination of activities between neighbouring countries and those countries involved in fresh fruit trade is leading to more effective regional management of the fruit fly pest.

1.1 ACIAR Research Projects

ACIAR has supported fruit fly research in developing countries since 1984. Two projects, based in Thailand and Malaysia, have generated significant scientific and economic outcomes. The total cost of these two projects was $1.7m (in 1996 dollars). Specific outcomes include:

1. A more detailed understanding of exotic fruit fly species, their host range, pest status and spatial distribution;
2. Increased interest in fruit fly management in Thailand and Malaysia and throughout the South Pacific; and
3. The demonstration of an effective protein bait spray technology.

1.2 Project Benefits

While the two ACIAR research projects carried out in Malaysia and Thailand between 1984 and 1993 have generated economic gains in these countries, considerable benefits have been realised in Australia. These benefits include:

- a saving of $0.76m because of the reduced time taken to carry out a delimiting survey following the papaya fruit fly outbreak around Cairns in 1995;
- a gain of $5.03m from the quicker realisation of papaya fruit fly eradication benefits;
- gains of up to $4m a year during the eradication of the papaya fruit fly from Australia as a result of continued access to premium fresh fruit export markets; and

- gains of up to $0.28m a year as a result of continued access to fresh fruit export markets during the eradication campaign rather than redirecting produce to the domestic market.

1.3 Economic Pay-Off

It was estimated that the two ACIAR research projects are likely to generate a net benefit, in present value terms, of nearly $10m (in 1996 dollars). This represents a return of over $9 for every dollar invested. The internal rate of return was estimated at 35%. Most of these benefits have already been realised, with over $7m in present value terms being realised to date.

2. Introduction

This cost benefit analysis was undertaken for the Australian Centre for International Agricultural Research (ACIAR). ACIAR is a statutory authority within the Federal Government's Department of Foreign Affairs and Trade. It provides funds for collaborative research between Australian research organisations and those in developing countries. ACIAR's investment is part of Australia's overseas aid program which seeks to assist developing countries in solving serious agricultural production problems and to contribute to the development of strong and harmonious relationships between Australia and developing countries (Ahern 1997).

The two ACIAR projects evaluated in this study are :

- CS8343 Study of economically important fruit flies in Malaysia and development of control methods and

- CS8919 Biology and control of fruit flies in Thailand and Malaysia.

The objectives of these two ACIAR projects were to identify the most economically important fruit fly species in Malaysia and Thailand, to determine their host range and geographical distribution, and to develop improved methods of control in commercial fruit growing operations.

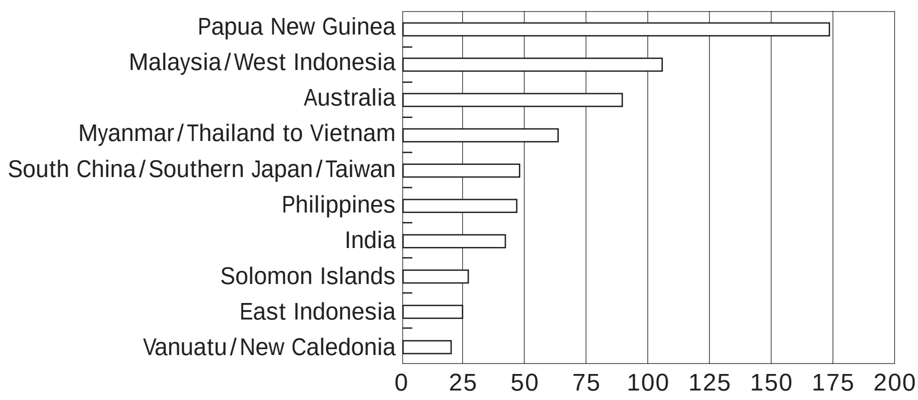
In this study the economic return on funds invested in ACIAR projects CS8343 and CS8919 is estimated. The following section presents an overview of the fruit fly problem in terms of its economic significance. In section 3 details of project costs and outcomes achieved are discussed. Benefits which can be attributed to the ACIAR projects are examined in section 4. The report concludes with an assessment of the economic return on funds invested in the two ACIAR projects and whether or not this investment has represented '*value for money*'.

3. The Fruit Fly Problem

Fruit flies impose a significant cost on horticultural production every year. The world market for fresh fruit has been estimated at US$772 billion in 1995 (Armstrong and Jang 1997). There is also a significant amount of fruit production in subsistence-based agricultural production systems. Because of the potential losses from fruit fly infestations, considerable funds are invested world-wide in quarantine programs. The economic cost of fruit flies to Australia alone is estimated at $125m per annum (Vickers 1994).

Fruit flies belong to the family Tephritidae, and there are over 4,000 species in this family. There are more than 800 species in the sub-family Dacinae which are the main species that infest soft fruits in tropical and sub-tropical areas (Bellas 1996). In Figure 1 the number of Dacinae species within the South-East Asia and Pacific region is shown. The largest numbers of Dacinae species are found in Papua New Guinea, Malaysia/West Indonesia and Australia.

Figure 1. Distribution of fruit fly species in the sub-family Dacinae



Source : Drew & Romig (1997a)

3.1 On-Farm Implications

Production

Fruit flies are attracted to host plants when fruit is developing. Different fruit fly species have different host ranges. Fruit flies feed and breed around their host plants and lay eggs in the ripening fruit (Drew & Romig 1997b). When the larvae or maggots emerge they feed off the ripening fruit. This can cause fruit to drop prior to harvest, or if harvested, the resultant damage makes the fruit unsaleable.

Typically, the pest status of a fruit fly species is reported in terms of the percentage of a fruit crop infested by the fly. In some fruits losses can be very high. Tobin (1990) reports losses close to 100% in carambola and guava plantings in Malaysia and Allwood and Leblanc (1997) report losses of 60% in cumquat, 89%–97% in chilli and 20%–25% in mangoes across seven Pacific Island countries.

Control

Because of the potential losses from fruit fly infestations, control is typically carried out on a routine basis, especially in commercial plantings. Fruit fly management involves application of insecticides, although the removal of infested or fallen fruit can reduce fly populations to some extent, and the practice of bagging can lessen damage to individual fruit. The most common insecticide application method is cover sprays, although the use of protein bait sprays is gaining increasing popularity as improved attractants and feeding stimulants are developed (Ferrar 1988).

Environmental

An indirect loss from the use of cover sprays is the impact on other insect species which are beneficial to production. These species include pollinators and natural parasites and predators of other fruit pests. The intensive use of sprays in fruit crops can also elevate growers’ risk of exposure and the potential for long term health problems.

3.2 Quarantine Implications

Early detection

Fruit flies are endemic in many countries throughout Asia and the South Pacific. The potential on-farm costs associated with an outbreak of an exotic fruit fly species can justify government investment in early detection programs. The purpose of an early detection system is to identify and define incursions of targeted exotic fruit fly species into a country (Cole and Koppman 1997). Expenditure on early detection programs tends to operate on a fixed budget with programs developed around the most cost-effective use of available funds. Early detection is not a single activity, but an organised program of trapping, monitoring and reporting across identified high risk areas. Programs are developed to maximise the likelihood of detecting an incursion before it becomes established (Frampton 1997).

Containment of new introductions

If an exotic fruit fly incursion occurs, response plans are implemented. These plans aim to keep the incursion localised through the establishment of quarantine areas and restrictions on the movement of fruit out of those areas. Intensive monitoring through trapping and fruit collecting is undertaken to gather information on the pest's breeding centres, range of hosts and rate of geographical spread. Host records from other countries are useful in evaluating the likelihood that a particular plant species could be a host plant, and therefore enables potential breeding 'hot' spots to be identified quickly. However, because the range of host fruits is often incomplete, additional surveillance and monitoring is usually required. Pre-determined grid patterns are typically used for this purpose.

Within the quarantine area, fruit trade restrictions can have a significant economic impact on growers. Growers can lose access to premium markets unless fruit is disinfested prior to export. The cost of disinfestation variesbetween countries, but is seen as a significant cost. In Australia, disinfestation costs are around $80 to $100 per tonne depending on the type of fruit (Australian Bureau of Agricultural and Resource Economics [ABARE] 1995).

Eradication

If a decision is made to eradicate the introduced pest then containment is extended to include measures that will together ultimately eradicate the pest. Eradication methods include (Bellas 1996):

- annihilation of males—lure traps are placed throughout the quarantine area to attract male flies which are then killed with an insecticide treated bait;

- bait sprays—an insecticide and attractant are placed in a trap, as a spot bait, or sprayed on foliage of host plants to attract and kill females before they can develop and lay eggs; and

- sterile insect technique (SIT)—large quantities of male flies are reared and sterilised by irradiation before release into the quarantine area. Mating with the sterile males results in sterile eggs and is an effective population suppressor when the fly population is low.

Eradication costs can be significant. For example, the Queensland papaya fruit fly eradication program will cost close to A$35m by the planned completion date in 1999 (Queensland Department of Primary Industries [QDPI] 1998, pers. comm.). Mediterranean and Oriental fruit fly incursions in the USA have occurred since 1980 and have been eradicated at a total cost of US$350m (Armstrong and Jang 1997).

The number of outbreaks of fruit flies each year is considerable. In South Australia there are over three outbreaks of the Queensland fruit fly and one to two outbreaks of the Medfly each year (Bailey and Cartwright 1994). On an international basis, fruit fly species breaking quarantine barriers since 1995 have included (Drew 1998, pers. comm.):

- papaya fruit fly into Papua New Guinea, Torres Strait islands and north eastern Australia;
- Oriental fruit fly into Tahiti, Palau and Mauritius;
- melon fruit fly completed movement across Solomon Islands and was detected in a trap in Western Australia, but it did not become established;
- papaya, and Queensland fruit flies and Medfly recorded in New Zealand; and
- four different fruit fly species into California.

4. ACIAR Research Projects

ACIAR has supported fruit fly research in South-East Asia and the Pacific since 1984. The topic of this evaluation is two particular ACIAR projects carried out in Malaysia and Thailand. Both projects were carried out under the leadership of Dr Dick Drew, currently a professor at the Australian School of Environmental Studies, Griffith University. A breakdown of annual costs of the projects is shown in Figure 2.

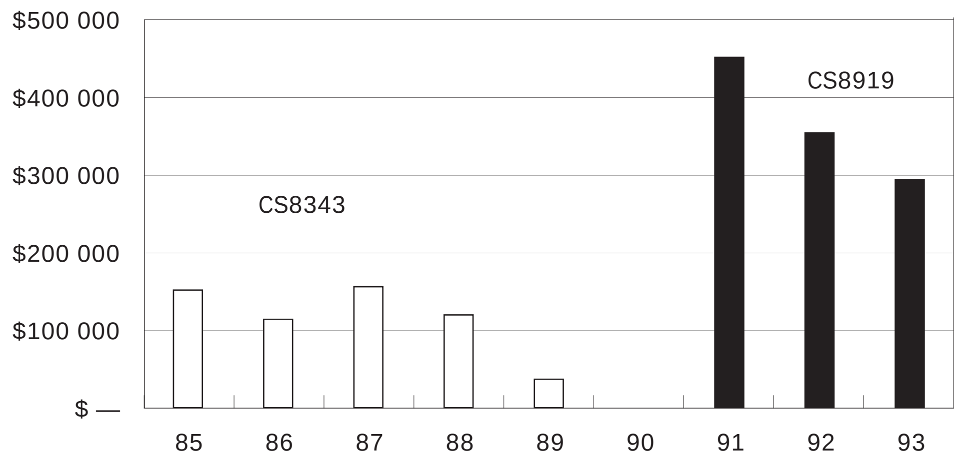
1. Project CS8343 – Study of economically important fruit flies in Malaysia and the development of control methods

This project began in September 1984 and ended in 1989. A total of A$397 692 was allocated to the project for collaborative research between QDPI and the Malaysian Agricultural Research and Development Institute (MARDI). The primary aim of the project was to clarify the taxonomic identity and biological characteristics of fruit flies in Malaysia so that their pest status and spatial distribution could be determined. A secondary aim was to develop improved field control treatments.

2. Project CS8919 – Biology and control of fruit flies in Thailand and Malaysia.

This project was started in July 1990 and ran through to June 1993. A total of A$1 007 827 was allocated for collaborative research between QDPI, MARDI and Thailand's Prince of Songkla University and Department of Agriculture. The main aim of this project was to extend the work carried out under Project CS8343 to Thailand and eastern Malaysia. A secondary aim was to further develop the protein bait spray technology that was used for fruit fly control in Malaysian carambola orchards.

Figure 2. Project costs (1996 Dollars)



Project reviews were carried out for ACIAR in 1989 and 1994. These reviews identified several outcomes which can be attributed to the ACIAR funded work.

▶▶▶▶ 1. The main outcome from ACIAR's research effort in Thailand and Malaysia has been a more detailed understanding of the Oriental fruit fly complex. Research has shown that this complex is made up of at least 52 sibling species that occur throughout tropical Asia. Extensive trapping and rearing of flies from fruit has enabled the host and pest status of these species and their geographical distribution to be defined. The work has shown that the true Oriental fruit fly (*Bactrocera dorsalis*) does not occur in Malaysia. Other pest fruit fly complexes, such as the curcurbit infesting groups, have also been studied.

As a result of the increased understanding of fruit flies, their host species and seasonal and spatial distribution, it has been possible to undertake better assessments of the quarantine risks in Thailand and Malaysia. It has also enabled countries importing fruit from these countries better assess quarantine risks associated with the fruit fly species studied in the two ACIAR projects.

▶▶▶▶ 2. The research has stimulated considerable interest in fruit fly management in Thailand and Malaysia and many other countries throughout South-East Asia and the Pacific. To a significant degree this interest was responsible for the holding of the first International Symposium on Fruit Flies in the Tropics in March 1998 (ACIAR Project Review). ACIAR now directs funding support to specific initiatives, such as training workshops, under the Regional Fruit Fly Project being carried out in the South Pacific by the United Nations Development Program, Food and Agriculture Organization, AusAID and the South Pacific Commission. A more coordinated approach to regional quarantine can help minimise fruit fly problems in all countries and prevent the spread of species to areas where they do not occur at present (Drew and Allwood 1997).

▶▶▶▶ 3. It was demonstrated that bait spraying was an effective farm level control strategy and that local, low cost sources of protein product could be used. A bait spray—PROMAR—was developed and its marketing rights granted to MARDI. Uptake of the bait spray in Malaysia and Thailand has been limited, although it is now a recommended standard treatment. Further investment in proactive extension programs to farmers in these countries could help unlock the spray bait's full potential. Demonstrated success of the bait spray overseas has stimulated greater interest in its application in Australia. ACIAR funded some extension work in Queensland in 1993, and as a result the use of protein bait sprays as a method of fruit fly control has increased.

5. Economic Benefits of the Projects

The two ACIAR research projects conducted in Thailand and Malaysia have made a substantial contribution to increasing the scientific understanding of the fruit fly pest in Southeast Asia and the Pacific. Tobin (1990) reported that a gain of $220 for every dollar invested by ACIAR in project CS8343 could be realised if the protein bait spray technology was taken up by carambola and guava growers in Malaysia. This technology has not yet been taken up to any significant extent, and further extension work is needed to realise these potential gains.

Research outcomes have also enhanced regional cooperation throughout the South Pacific and in Southeast Asia. McGregor (1997) estimated that the Regional Fruit Fly Project in the South Pacific, over the period 1990 to 2002, is likely to generate a return on investment of 37%, as measured by the internal rate of return. While the ACIAR projects have stimulated the initial interest in regional cooperation, it would be inappropriate to attribute potential regional benefits solely to the two ACIAR projects examined in this report.

Because of the difficulty in separating out the quarantine and trade benefits in Southeast Asia and the Pacific that could be attributed solely to the two ACIAR projects, assessment of project benefits in this study focuses on the gains that have been realised in Australia. Research outcomes have decreased the risk of exotic fruit fly incursions into Australia because of more effective regional control and increased the effectiveness of the papaya fruit fly eradication program which was implemented in Queensland following an outbreak in 1995.

5.1 Regional Control

With better regional control of fruit flies throughout South-East Asia and the Pacific, the likelihood of an incursion of an exotic fruit fly species will be reduced. This can occur in two ways: (i) more effective quarantine and fruit fly control programs across the region will result in less fruit flies being ‘exported’ to other countries such as Australia, and (ii) correct identification of a wider range of fruit fly species reduces the probability of misidentification of an incursion into Australia, and therefore saves unnecessary expenditure on further surveillance, containment and eradication.

The risk of an exotic fruit fly infiltration into Australia in any given year is unknown. Hence potential cost savings have not been estimated in this study, however any decrease in this risk could deliver substantial cost reductions. Vickers (1994) estimated that $10m a year is spent by the Commonwealth and State governments on international quarantine, monitoring, eradication, provision of advisory services and postharvest disinfestation research.

5.2 Papaya Fruit Fly Eradication

An outbreak of the papaya fruit fly was found near Cairns in October 1995. On 16 November 1995 a team was assembled in Cairns to investigate the extent and severity of the infestation (Bellas 1996). Following an assessment of the potential economic damage from this pest it was decided that an attempt would be made to eradicate it. A national eradication program was then implemented, with funding and coordination provided through the Standing Committee on Agricultural and Resource Management (Plant Health Committee). The QDPI was responsible for the management of the eradication program.

The eradication program is expected to run through to the middle of 1999, at which time it is anticipated that the papaya fruit fly will have been eradicated. The cost of the extermination program is expected to be over $34m as detailed in Table 1. These expenses relate only to the direct costs of the campaign and do not include farm level control outlay, postharvest treatment costs or expenses incurred as a result of the anxiety created within the quarantine area.

Table 1. Papaya fruit fly eradication costs ($'000)

	Year				
Cost item	95–96	96–97	97–98	98–99	Total
Research and development	50	490	606	376	1 522
Monitoring	800	2 588	3 168	1 983	8 539
Eradication	2 093	5 283	4 610	238	12 224
Quarantine	2 344	3 411	4 132	1 606	11 493
Sterile insect technique (SIT)	0	96	400	0	496
Total	5 287	11 868	12 916	4 203	34 274

Source : Queensland Department of Primary Industries

Factors which are thought to have contributed to the success of the papaya fruit fly eradication campaign include (information supplied by QDPI):

- a strong tradition of fruit fly research and control in QDPI extending over 40 years;
- ability to rapidly mobilise resources for the initial response;
- success in gaining national cost-sharing;
- formation of a section in QDPI to optimise preparedness and response against exotic pests and diseases;
- effective transfer of emergency response principles from animal industry experience;
- appointment of a strong scientific team and capable support staff;
- rapid establishment of trapping and fruit collection grids to define limits of infestation;
- success of the initial intensive eradication effort which essentially reduced the fly population to manageable levels by the end of the 1995–96 wet season; and
- in general, excellent industry and community cooperation.

The outcomes obtained from the two ACIAR projects have had a major impact on the effectiveness of the eradication campaign, and this is widely recognised. However, it is difficult to separate out the contribution of the ACIAR work to the success of the program and the $893m in economic gains generated (ABARE 1995). A breakdown of the annual benefits from eradication, as estimated by ABARE (1995), is presented in Table 2. ABARE (1995) notes that these benefits are likely to understate total gains as no account is made for possible environmental impact or the effect on non-horticultural industries and ‘back yard’ production.

Table 2. Annual benefits from papaya fruit fly eradication($ [1996] Millions)

Benefit (Costs avoided)	Quarantine zone	Rest of Australia	Australia
Disinfestation cost for export market	0.08	7.70	7.78
Cost of insecticide sprays	0.38	54.23	54.61
Disinfestation cost for domestic market[a]	12.99	0	12.99
Total	13.45	61.93	75.38

[a] Cost is only incurred while the outbreak remains localised.

Source : ABARE (1995) Table 3.2, page 15.

In the estimation of benefits from research, it was necessary to differentiate between the situation with or without the ACIAR projects.

5.3 The Situation Without the ACIAR Projects

If there was a fruit fly outbreak in the absence of the knowledge collected during the ACIAR projects:

- It would take time to design and undertake a delimiting survey, and would take longer to achieve eradication of the fruit fly. In some cases, depending on the knowledge of the pest species and the geographical area of infestation, delimiting survey work can take up to two months (Dick Drew 1998, pers. comm .).

- Producers of fruit and vegetables susceptible to fruit flies would lose access to some markets, particularly in countries which are free of fruit flies. These countries would place quarantine barriers to Australian fruit and vegetable exporters.

- Fruit and vegetable producers, having lost markets in the fruit fly free countries, would re-direct export produce to the domestic market, and to markets endemic with fruit flies.

5.4 The Situation With the ACIAR Projects

The results from the ACIAR projects imply that there are four impacts:

- Delimiting surveys will take a shorter time to design and administer;

- Time saved in undertaking the delimiting survey will allow eradication to be achieved earlier than ‘without ACIAR projects’;

- Australian producers can have access to export price-premium markets in non-endemic countries—a benefit for exporters of fruit and vegetables;
- In addition, there will be a net welfare gain in Australia and in other fruit fly endemic markets. This net welfare gain is made up of:
  - Gains to fruit and vegetable producers, as the domestic price of fruit and vegetables will be higher than without the project; and
  - A loss in consumer surplus in Australia as domestic prices of fruit and vegetables will be higher.

The rest of the section discusses how these four items were estimated in the case of the 1995 outbreak of papaya fruit fly in Queensland.

Delimiting survey—cost saving

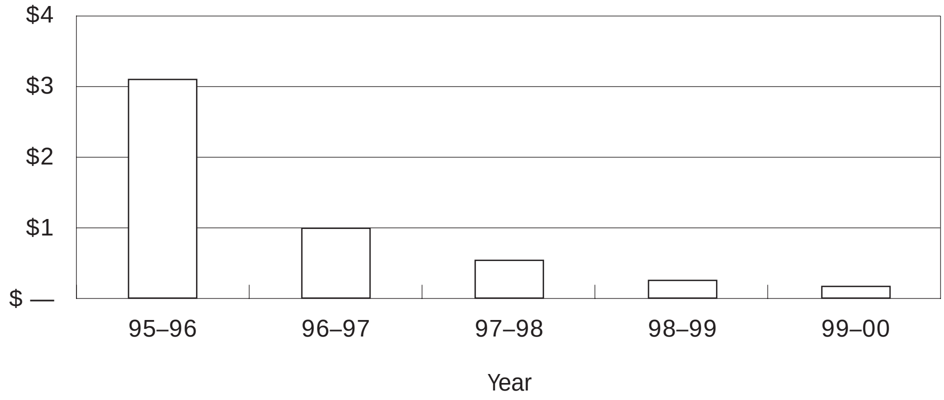
Population suppression started within one month from notification of the outbreak. Traps were initially placed using a grid system to determine the limit of spread of the fruit fly. Knowledge of the species and its host range gained from the ACIAR work in Thailand and Malaysia enabled the trapping grid to be refined through time and improved the targeting of potential breeding 'hot' spots.

The average daily cost of the papaya fruit fly eradication program is estimated at just over $25 000. This time saving of one month generates a one-off benefit of $0.76m. This cost saving is shown in the Summary of Benefits (Table 4) against the year 1998–99.

Acceleration of progress toward successful eradication

The time saved in making the delimiting survey will accelerate the realisation of eradication benefits. In Figure 3 these additional benefits are given. In calculating these benefits, estimations made by ABARE (1995) were converted from annual to monthly gains, and it was assumed that eradication will be successful and achieved in 1999. These benefits are shown under the heading 'Accelerating benefits' in Table 4.

Figure 3. Gains from achieving eradication benefits earlier ($ [1996] Millions)



Export Premium

Trade protocols regarding the export of fruit from fruit fly endemic countries vary depending on the requirements of the importing country and the type of fruit traded. At the declaration of the papaya fruit fly outbreak in Queensland it seemed probable that Australian exports of fresh fruit sourced outside the quarantine area would need to undergo postharvest disinfestation treatments prior to shipment to papaya fruit fly free markets (such as Japan and New Zealand). However, Australian Quarantine Inspection Service (AQIS) negotiations with Australia's major trading partners were successful in obtaining area freedom concessions for produce sourced outside the quarantine area. The success of these negotiations can be attributed to the extensive trapping program throughout Australia and the scientific knowledge of the papaya fruit fly, its host fruits and pest status. These concessions enabled continued access to papaya fruit fly free export markets and prevented the redirection of export produce to the Australian domestic market.

The benefits from the export premium depend on three factors:

- total volume of exports,
- premium per tonne received per tonne of export in non-endemic markets, and
- percentage of the exports sold in non-endemic markets.

Exports

In 1994–95 Australia exported 131 kt of the fresh fruits which are the main hosts of the papaya fruit fly and are produced to some extent in the quarantine zone. These exports account for nearly 10% of Australian production. However, while the percentage varies by commodity, Table 3 indicates that, on average, only two percent of these exports are produced in quarantine areas in Australia. Most are produced outside the quarantine zone and would have been adversely affected if the whole of Australian production were to be quarantined.

Table 3. Australian fruit production & fresh fruit exports: 1994–95

Product	Quantity produced (t)	Price ($ kg)	Quantity exported (t)	Percent of total exports sourced from quarantine area in Australia (% by value)
Avocados	15 640	2.53	269	5%
Bananas	208 102	1.23	465	91%
Citrus	609 745	0.50	108 113	0.1%
Capsicum	27 662	1.48	207	1%
Mangoes	29 603	2.47	3 683	19%
Melons	142 188	0.53	12 705	6%
Papaws	6 225	1.12	11	46%
Tomatoes	340 933	0.49	5 910	1%
Total	1 380 098	0.70[a]	131 363	2%

[a]Average price received by growers

Source : Australian Bureau of Statistics (ABS 1997) and ABARE (1995)

Premium

Export sales of fresh fruit to papaya fruit fly free markets attract an average premium of around 9% (ABARE 1995). The premium per tonne (about $62.70/tonne) is equal to the quantity weighted price of 70 c/kg ¥ the premium of 9% (ABARE 1995) ¥ 1000.

If the value of the premium exceeds the cost of a disinfestation treatment, exports would be maintained and the disinfestation cost incurred. However, non-endemic markets may not accept the disinfestation treatment, and in fact suitable disinfestation treatments are still being developed for the papaya fruit fly. Because of the successful negotiation of area freedom concessions it has been possible to maintain exports to papaya fruit fly free markets without the need for any disinfestation treatments. Of the exports in Table 3, about 46% were sold in papaya fruit fly free markets (based on unpublished Australian Bureau of Statistics [ABS] data). The value of this benefit is estimated at $3.8m a year (that is total exports in Table 3 ¥ 46% ¥ the premium per tonne). This benefit will continue to be realised until the papaya fruit fly is successfully eradicated from northern Queensland.

In Table 4 the premium related benefits are shown under the heading 'premium'. The estimate for 1995/96 covers only seven months and is given by $3.79m ¥ 7/12 ¥ 0.0556 (the Consumer Price Index [CPI]) which equals $2.33m. The premium related benefits for the other three years in Table 4 are given by $3.79m ¥ 0.0556 (CPI), that is $4.0m per year.

A net welfare gain in Australia and in other fruit fly endemic markets

A situation with the ACIAR projects generates welfare changes in Australia and other fruit fly-endemic markets, as indicated below.

Increase in producer surplus on produce sold on the Australian market

Without the ACIAR projects, export produce would have been redirected to the domestic market (or other papaya fruit fly endemic markets). Increased supply of fresh fruit on the domestic market would depress fruit prices.

However with the results from the ACIAR projects, and in presence of a fruit fly outbreak, access to papaya fruit fly free markets was not restricted and export production was not redirected to the domestic market. Thus prices were much higher than they would have been without the ACIAR projects. Thus there is a gain in producer surplus.

In 1994–95 some 1.38 kt of the fruits listed in Table 3 were produced in Australia at a quantity weighted average farm level price of 70 c/kg (ABS 1997). Of this total production, 1.32 kt was consumed on the domestic market with the rest exported to papaya fruit fly free markets. Without the ACIAR projects, the domestic market average price of fruit would have been about 69 c/kg. (This calculation is based on a supply elasticity of 1.5 and a demand elasticity of –2.0). The gain in producer economic surplus would be $12.02m each year.

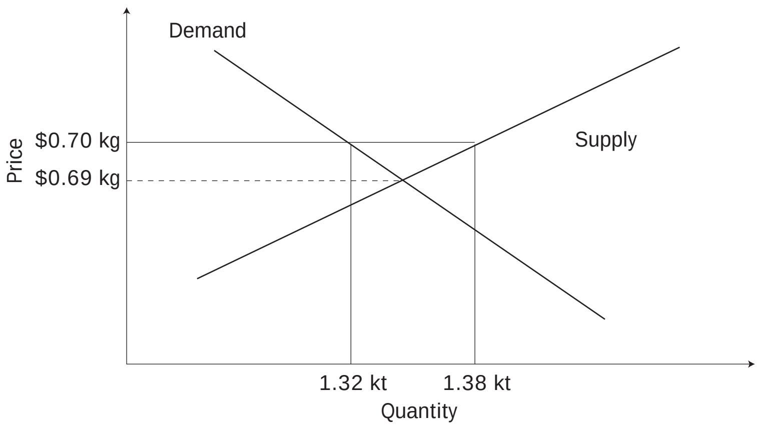
Loss in consumer surplus on produce sold on the Australian market

With the ACIAR project the domestic price is higher for fruit and vegetables than it would have been without the project. This leads to a loss in consumer surplus of $11.76m a year.

The net gain

The net gain (on the domestic market) in economic welfare (with the project) is estimated at $0.26m a year (the difference between an increase in producer surplus of $12.02m and a decrease in consumer surplus of $11.76m). This would accrue until the successful eradication of the papaya fruit fly from the quarantine area. (The algebraic calculations for estimating the loss in economic surplus are provided in the Appendix.) The changes in economic welfare are described in Figure 4.

Figure 4. Loss in economic welfare



In the first year of the outbreak (with the ACIAR project) the gain in economic welfare (compared to without the ACIAR project) would be higher because the ability of growers to respond to the situation (without the ACIAR project) would be limited. In the first year of the outbreak it is estimated that the net gain in economic welfare is $0.23m. This is given by $0.26m (the annual net welfare gain) ¥ 1.42 (to allow for the higher gain in year 1) ¥ 1.0556 (CPI) ¥ 7/12 (only the last seven months of year 1 were affected). The net gain (on the domestic and fruit fly endemic markets) in the other three years (1997 to 1999) are equal to $0.26 ¥ 1.0556 (CPI) = $0.28m.

5.5 Summary of Benefits

The total estimated benefits from the two ACIAR projects are reported in the last column of Table 4.

Table 4. Summary of project benefits: $ (1996) millions

Year	Papaya fruit fly eradicationdelimiting survey				
	Cost saving	Acceleration of benefits	Premium on export price	Redirection of fruit and vegetables	Total benefit
93–94					
94–95					
95–96		3.14	2.33	0.23	5.70
96–97		1.01	4.00	0.28	5.29
97–98		0.50	4.00	0.28	4.78
98–99	0.76	0.25	4.00	0.28	5.29
99–2000		0.13			0.13
Total	0.76	5.03	14.33	1.07	21.19

Note: benefits generated in 1995–96 have been adjusted to account for the start of the outbreak in October, 1995.

6. Economic Evaluation

The estimated economic pay-off from the ACIAR funded research in Thailand and Malaysia is presented in Tables 5 & 6. Usual economic performance measures, including the net present value, benefit cost ratio and the internal rate of return of the investment in the research projects are reported.

Table 5. Project pay-off : benefits over 30-year time horizon

Performance measure	Source of benefit		
	Delimiting survey	Area freedom	Total
Present Value of Benefits ($m)	3.09	7.91	11.00
Present Value of Costs ($m)			1.27
Net Present Value ($m)			9.73
Benefit Cost ratio			9
Internal Rate of Return (%)			35

Note: a discount rate of 5% was used. Benefits and costs are expressed in 1996 dollars.

Table 6. Project pay-off : benefits to date

Performance measure	Source of benefit		
	Delimiting survey	Area freedom	Total
Present Value of Benefits ($m)	2.54	5.85	8.39
Present Value of Costs ($m)			1.27
Net Present Value ($m)			7.13
Benefit Cost ratio			7
Internal Rate of Return (%)			33

Note: a discount rate of 5% was used. Benefits and costs are expressed in 1996 dollars.

►►►► It was estimated that the two ACIAR funded projects in Thailand and Malaysia will generate a net benefit to the Australian economy of some $11m in present value terms.

The internal rate of return was estimated at 35%. The majority of the projects' benefits have already been realised. The estimated net benefit realised to date is estimated at $7.13m in present value terms. These returns represent an attractive rate of return on ACIAR's investment in the two projects. Apart from these tangible returns, the increased level of interest in fruit fly control and quarantine management throughout Southeast Asia and the South Pacific engendered by the two ACIAR projects will contribute to the development of strong and harmonious relationships between Australia and developing countries.

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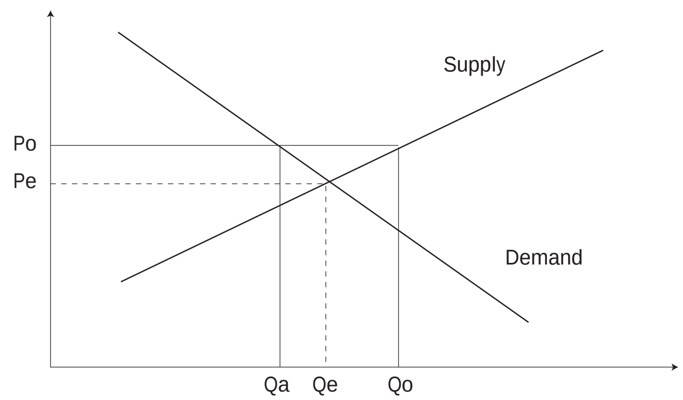
Appendix
Calculation of Economic Surplus Loss

The redirection of fresh fruit exports from non-endemic papaya fruit fly markets to the Australian market results in a loss of economic welfare as measured by the net change in producer and consumer surplus. Prior to the papaya fruit fly outbreak Australian fruit production can be represented by Qo in Figure A1. Of this production (Qo), Qa is sold on the domestic market at Price Po and the difference is exported to non-endemic papaya fruit fly markets. Because Australia accounts for a relatively small share of world fresh fruit exports it is assumed that the export demand for Australian fresh fruit is perfectly elastic.

Following the Papaya fruit fly outbreak, export produce (Qo-Qa) is redirected to the Australian market. As a result, fruit prices fall to Pe. Consequently, there is a gain in consumer surplus and a loss in producer surplus. The difference is the net loss in economic welfare.

Figure A1. Australian fruit supply and demand



Algebraically

Parameters

Elasticity of supply	es
Elasticity of demand	ed
Australian fruit demand	Qd
Australian fruit supply (excludes exports to papaya fruit fly endemic markets)	Qs
Pre-outbreak production	Qo
Pre-outbreak domestic consumption	Qa
Pre-outbreak price	Po
Post outbreak production	Qe
Post outbreak domestic consumption	Qe
Post-outbreak price	Pe

Demand Equation (assume linear) :

(1) P = bdQd + gd (P is price)
where bd = (Po/Qa)(1/ed)
gd = (Po – bdQa)

Supply Equation (assume linear):

(2) P = bsQs + gs (P is price)
wherebs = (Po/Qo)(1/es)
gs = (Po – bsQo)

Pre-outbreak Producer Surplus (PSo):

(3) PSo = 0.5Qo(Po – gs)

Pre-outbreak Consumer Surplus (CSo):

(4) CSo = 0.5Qa(gd – Po)

Post-Outbreak Production / Consumption:

(5) Qe = (gd – gs)/(bs – bd)

Post Outbreak Price:

(6) Pe = bdQe + gd

Post-Outbreak Producer Surplus (PSe):

(7) PSe = 0.5Qe (Pe – gs)

Post-Outbreak Consumer Surplus (CSe):

(8) CSe = 0.5Qe (gd – Pe)

Change in Producer Surplus (DPS):

(9) DPS = PSe – Pso

Change in Consumer Surplus (DCS):

(10) DCS = CSe – Cso

Change in Economic Welfare (TS):

(11) TS = DPS + DCS