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Economic evaluation of three alternative methods for control of the Mediterranean fruit fly (Diptera: Tephritidae) in Israel, Jordan, Lebanon, Syrian Arab Republic and Territories under the Jurisdiction of the Palestinian Authority

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ECONOMIC EVALUATION OF THREE ALTERNATIVE METHODS FOR CONTROL OF THE MEDITERRANEAN FRUIT FLY (DIPTERA: TEPHRITIDAE) IN ISRAEL, JORDAN, LEBANON, SYRIAN ARAB REPUBLIC AND TERRITORIES UNDER THE JURISDICTION OF THE PALESTINIAN AUTHORITY
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FOREWORD

Extensive fresh fruit and vegetable production industries are developing in many parts of the world in response to the large demand for high quality fresh fruits and vegetables. Tephritid fruit flies, however, cause devastating direct losses to many of the fresh fruits and vegetables that investors target for the market place thus requiring regular insecticide treatments to protect the crop. In addition, few insects have a greater impact on international marketing and world trade in agricultural produce than the tephritid fruit flies. With expanding international trade, fruit flies, as major quarantine pests of fruits and vegetables, have taken on added importance. This will trigger additional demands by the Food and Agriculture Organization (FAO) and the International Atomic Energy Agency (IAEA) Member States to implement area-wide national or regional (transboundary) control programs against fruit fly pests.

The fresh fruit and vegetable industry is facing the dual demand of rapidly rising population in developing countries which requires more production for food security and nutrition as well as a demand by developed country importers for products with pesticide residues below critical levels. As part of this process new areas are being brought into production, which require control of fruit fly pests.

Developed importing countries are giving increased attention to food safety issues, partially driven by the BSE crisis, food adulteration in Western Europe and outbreaks of food borne infections in the US. Concerns over insecticide residues in fresh fruits and vegetables have become widespread particularly as it affects children who are believed to be more vulnerable. These concerns are leading to changes in regulations of permissible pesticide residues. Thus, fruit fly control methods that require minimum insecticide use are welcomed by wholesalers and consumers alike.

As part of globalization, trade in fresh fruits and vegetables is being liberalized on a worldwide basis. The issues of this trade are considered in many forums, among them the World Trade Organization (WTO), Codex Commission of the Joint FAO/WHO Food Standards Programme, the International Plant Protection Convention (IPPC) of FAO, and other organizations with SPS (Sanitary and Phytosanitary Standards) issues in the forefront of concerns. In order to be able to export their products many developing countries must comply with increasing stringent SPS measures being mandated. Pesticides are less and less acceptable and ways must be found to facilitate production to meet these requirements, which in turn provide trading opportunities to many developing countries. Newly adopted International Standards for Phytosanitary Measures under the IPPC of FAO serves to expand such opportunities through the establishment of areas of low prevalence, pest (fruit fly) free areas, systems approaches, etc.

The Sterile Insect Technique (SIT) offers a comprehensive and effective alternative to chemical control, mitigating environmental and health concerns. Integration of the SIT with other control techniques offers the opportunity to control the pest over much of a geographical region, and will permit in the absence of insecticide sprays the implementation of effective biological control schemes against secondary insect pests. Applied for pre-harvest-control, as part of a systems approach in combination with post-harvest treatment of fruit, SIT used for routine control rather than eradication purposes does not preclude the creation of internationally recognized fly free or low prevalence areas to overcome these trade barriers to agricultural produce.

Major breakthroughs from FAO/IAEA research and development, particularly the development of genetic sexing (male only) strains and improved rearing systems, served to increase the efficiency of the SIT and lower operational costs. Commercial application of the SIT will drive operational costs even lower with further improvements in sterile fly production, handling and release methods.

The present benefit-cost analysis confirms the economic feasibility of this approach. The fact that SIT can be used for "control", and not solely for eradication, more than any other development, will open the doors to greater acceptance and use of the SIT in the future. Out of necessity, it also will lead to increased commercial use and sustainability of SIT technology. It eliminates the criticism often directed at the SIT that eradication is unrealistic, and unsustainable in many cases, for lack of adequate quarantines. Environmental elements will further reinforce the favourable cost-benefit economic analysis for the use of SIT as an alternative to purely chemical based controls.

In the Mediterranean region, where some of the initial medfly pilot SIT projects took place in the 1960s and early 1970s, many fewer advances have been made in the application of SIT, even though environmental concerns due to intensive insecticide use against medfly, particularly in coastal areas where tourism and fruit orchards coexist, are increasingly of major importance. The recent development of male-only strains, opening the possibility of using SIT for routine medfly control rather than eradication, has resulted in SIT programmes in various stages of development in Madeira, Israel, Jordan and the Palestinian Territories[1], as well as South Africa, and feasibility studies in Spain, Sicily and Maghreb countries in North Africa. This considerable activity indicates an increasing interest in the region in substituting medfly control based on insecticide sprays with environment-friendly medfly control based on SIT.

This economic assessment includes for Israel, Jordan, Lebanon, Palestinian Territories, and Syrian Arab Republic a brief background of the fruit industry, the medfly problem, environmental impact of current control methods, costs and benefits of three alternative area-wide medfly control options including the SIT and the economic indices. The study is designed to enhance the decision process of the countries public and private sectors that could be interested in participating in an area-wide SIT project and of donor agencies by providing an economic foundation for using area-wide control strategies.

The IAEA officer responsible for the preparation of this publication was W. Enkerlin of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

EDITORIAL NOTE

[1] The terms Palestine and Palestinian Territories throughout this document refer to the Territories under the Jurisdiction of the Palestinian Authority

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INTRODUCTION

The Mediterranean fruit fly or medfly (*Ceratitis capitata*, Wiedemann) is the single most important pest species affecting fresh fruits and vegetables within the Mediterranean region, but especially the Near East. The eggs laid by the adult females in fruit and vegetables generate larvae which feed within the pulp causing decay and premature fruit drop.

Fruit production of medfly hosts is valued at about US $1.1 billion per year in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic. If no control measures are applied against this pest, the annual fruit losses (i.e. only commercial fruit loss) would be approximately US $445 million which is almost 41% of the total annual revenue produced by fruits considered to be medfly hosts in these countries. Under the current medfly control programs, the direct damage (yield loss and control costs) and indirect damage (environmental impact and market loss) amount to US $298 million per year or 27.3% of fruit value. This amount could increase each year if the current insecticide-based control programmes are continued due to increased cost for pesticide registration and increase in market and environmental loss. Countries where the medfly is established have restricted access (requiring post-harvest treatment of their fruit) to export markets in those countries still free of this pest.

It is estimated that in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic, for medfly control, ca. US $190 million (US $13.6 million/year) would be spent in 14 years by farmers using current control practices. In addition another US $1.7 billion (US $118.7 million/year) would be lost, despite control, due to direct damage by the pest (i.e. commercial plus backyard fruit loss) and at least US $540 million (US $38.6 million/year) due to environmental impact costs. This amounts to a total loss of US $2.4 billion for the whole region in 14 years not including the market loss, which would add another US $127.4 million per year.

This study compares three area-wide medfly control strategies. These control alternatives include population suppression using bait sprays (BAIT-SUPP), population suppression using routine releases of sterile male flies (SIT-SUPP), and population eradication also using routine releases of sterile male flies (SIT-ERAD). The study analyses the economic impact of these improved alternative management tools for the Mediterranean fruit fly in the Middle East using a 14-year time frame. Since eradication using SIT is one of the options, its goal would not be achieved until the 9th year. A 14-year time frame provides an additional period of 5 years in which to assess the full impact of benefits obtained from eradication. Costs and benefits of the alternative control options are computed to estimate the economic indices (i.e. benefit to cost ratio, net benefit and pay back period). Additional adjustment for sterile male purchase and release costs were made based on actual costs incurred in the two national projects being conducted in Israel and Jordan.

Results indicate that the three area-wide control options are technically and economically feasible and all are better than the current control programmes. For each option, the economic returns on a medium and long term are discussed, along with the environmental impact. Both SIT options result in significant environmental benefits. US $309 million would be saved over a 14-year period by avoiding indirect damage such as secondary pest outbreaks, reduced pollination by bees, reduced honey production and treatment for human intoxications. Moreover, with the growing demand for organic agricultural products and the increasing willingness of consumers to pay a premium to growers for such fruit there is a noticeable

trend from intensive high input production systems to a more environment friendly agriculture. In the USA the current yearly rate of increase of sales of organically produced food is 20% and as much as 40% a year in some European countries. With medfly being the key pest for the major fruit crops in the Middle East, medfly SIT control, combined with the biological control of secondary pests, could be an important step towards developing an organic fruit production in this region without the need for medfly eradication. On a country basis the sterile male suppression option is the most sustainable and produces the highest economic returns. On a regional basis and over a 14-year time frame, the sterile male eradication option is economically only slightly more attractive than the SIT-SUPP option.

1. MIDDLE EAST CASE STUDY: ISRAEL, JORDAN, LEBANON, PALESTINIAN TERRITORIES, AND SYRIAN ARAB REPUBLIC

1.1. Introduction

The Mediterranean fruit fly (*Ceratitis capitata*, Wiedemann) is the single most important pest species affecting fresh fruits and vegetables within the Mediterranean basin, but especially the Middle East (FAO, 1995).

Fruits considered to be medfly hosts produce about US $1.1 billion per year in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic. If no control measures were applied against this pest, the annual loss in revenue (i.e. only commercial fruit loss) would be approximately US $445 million which is almost 41% of the total annual revenue produced by fruits considered to be medfly hosts in these countries. Under the current control programs the direct damage (yield loss and control costs) and indirect damage (environmental impact and market loss) amount to US $298 million per year. This amount could increase on a yearly basis if the current control programs are kept due to increase cost for pesticide registration and increase market and environmental cost.

An alternative to the classic methods to control the medfly is the Sterile Insect Technique (SIT). In different parts of the world (e.g. North, Central and South America, Japan, Australia, etc) the massive releases of sterile flies proved to be a technology capable of suppressing or eradicating fruit fly populations on an area-wide scale with negligible adverse effects to the environment (Hendrichs, 1996 and Schwarz *et al.,* 1989). In recent years this control method has become even more cost-effective due to new technological breakthroughs such as better diets for mass rearing, development of male only strains, increased precision in sterile fly releases and more sensitive monitoring networks (Hendrichs *et al*., 1995 and Orozco *et al*., 1994).

1.2. Objectives

The main objectives of the study are to establish the economic feasibility of three area-wide medfly control strategies in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic:

(1) Bait suppression
(2) SIT suppression
(3) SIT eradication

The study includes, for the four countries and the territories under the jurisdiction of the Palestinian Authorities, a background of the fruit industry and commercialisation, the medfly problem, the environmental impact, costs and benefits of the control options and the economic indices. The study is designed to enhance the decision process of the Middle East countries that have been included and of donor agencies by providing an economic foundation for using area-wide control strategies.

1.3. Problem definition

1.3.1. Fruit industry in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic

In the Middle East countries the elevation of the Golan Heights and of Mount Lebanon, the low land in the coasts and in the Jordan Valley and the oases in the desert areas provide optimal conditions for the production of a wide range of fruits. In this region, since ancient times, fruits have been an important ingredient in the diet of the people. Cultivation of olives, figs, dates, pomegranate and grapes has been a tradition. In modern times fruit production has diversified and intensified. Fruit production includes, apart from the traditional crops, the common citrus species (orange, mandarin, grape fruit, etc), temperate fruits such as apple, pear, peach, apricot, plum, nectarine and cherry and even subtropical fruits such as guava, mango, papaya, avocado, persimmon, loquat and banana. More recently and on a very small scale, exotic fruits such as kiwi, carambola and litchi have also been cultivated.

Fruit production and consumption is in the culture of the Middle East people. This statement can be supported by the fact that the annual per capita production of fruit for Israel is 109 kg, for Palestinian Territories 44 kg, for Jordan 69 kg, for Lebanon 76 kg and for Syrian Arab Republic 68 kg, which are well above the world average (Enkerlin and Mumford, 1995).

The following paragraphs, present a more detailed description of fruit production and commercialisation for each of the countries and territories that have been included in this study.

1.3.1.1. Fruit industry in Israel

The fruit industry in Israel uses high technology to produce high quality fruit. It supplies the demand of 5.7 million domestic consumers. Israel is self sufficient in fruit production although its citrus fruit export industry has been struggling for the past 15 years.

The fruit industry in Israel can be divided into three different types of production: citrus fruits, temperate fruits and subtropical/desert climate fruits.

In 1994 Israel's fruit industry generated revenues of nearly US $500 million. From this, US $337 million came from fruits considered to be medfly hosts. Citrus fruit output was US $168 million whereas the output of other fruit was US $169 million (Table 1) (Enkerlin and Mumford, 1995).

Citrus production has been traditionally export oriented. The worldwide citrus production surplus drastically reduced profitability and stronger competitors in the Mediterranean basis took over most of Israel's market share. The Israeli citrus industry reached a peak in the mid 1970's exporting over 900 000 tonnes of fresh fruits mainly to Western Europe and generating revenues up to US $300 million per year. It then started to fall until in 1993 when 240 000 tonnes were exported generating revenues of only US $192 million (Figures 1 and 2).

Table 1. Production and value of fruits considered to be medfly hosts in Israel in 1994 (Enkerlin and Mumford, 1995)

Crop	Area (ha)	Avg. Yield (tonnes/ha)	Price (US$/tonne)	Yield ('000 tonnes)	Value (US $mn)
Citrus:					
Shamouti	6000	40.00	140	240.00	33.60
Lates	4000	40.00	140	160.00	22.40
Grapefruit	9000	42.20	140	379.80	53.17
Easy Peelers	4030	21.50	200	86.65	17.33
Oroblanco	1000	30.00	600	30.00	18.00
Lemon	1100	20.00	250	22.00	5.50
Others	4450	20.00	200	89.00	17.80
Subtotal	**29580**			**1007.45**	**167.80**
Temperate:					
Table Grape	2455	22.50	500	55.24	27.62
Plum (Japanese)	1420	15.10	333	21.44	7.14
Plum (European)	604	15.10	283	9.12	2.58
Apple	4617	30.00	258	138.51	35.74
Pear	1400	21.30	542	29.82	16.16
Peach	3200	19.50	400	62.40	24.96
Nectarine	806	22.50	400	18.14	7.25
Apricot	870	15.10	400	13.14	5.25
Cherry	151	10.00	2083	1.51	3.15
Quince	28	10.00	258	0.28	0.07
Subtotal	**15551**			**349.59**	**129.92**
Subtropical:					
Mango	1686	17.50	966	29.51	28.50
Persimmon	850	19.30	333	16.41	5.46
Loquat	317	10.10	833	3.20	2.67
Guava	240	12.50	333	3.00	1.00
Litchi	150	2.20	1750	0.33	0.58
Figs	100	5.50	1108	0.55	0.61
Anona	35	10.00	967	0.35	0.34
Carambola	10	5.00	833	0.05	0.04
Subtotal	**3388**			**53.39**	**39.20**
Total	**48519**		**--**	**1410.43**	**336.92**

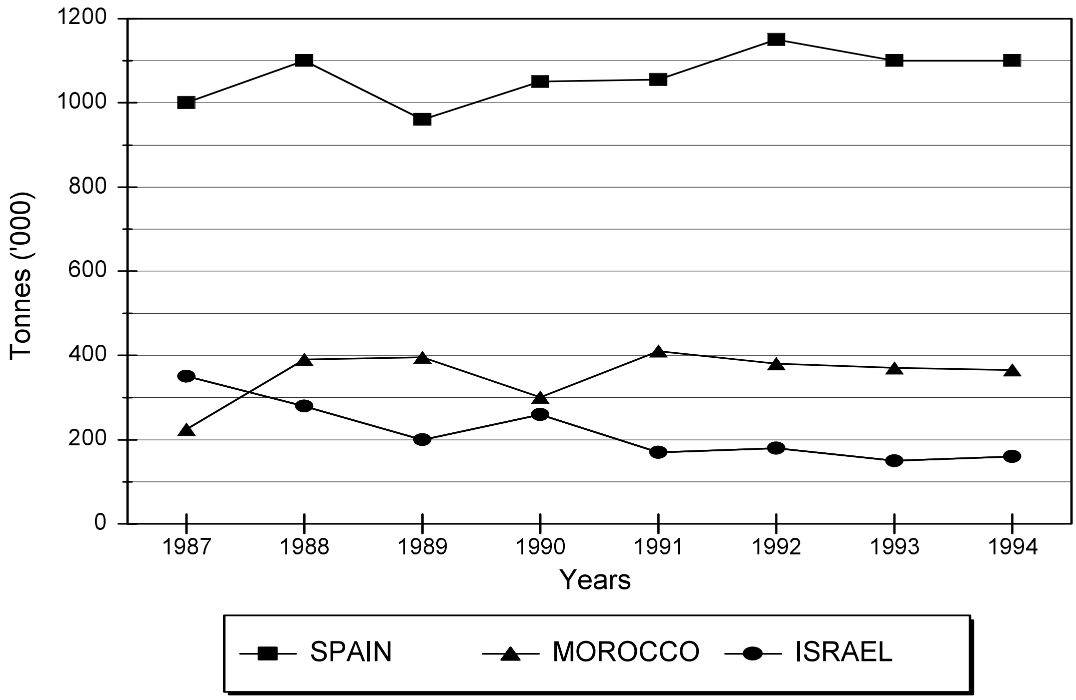

Figure 1. Israeli orange market share (Western Europe) (Enkerlin and Mumford, 1995).

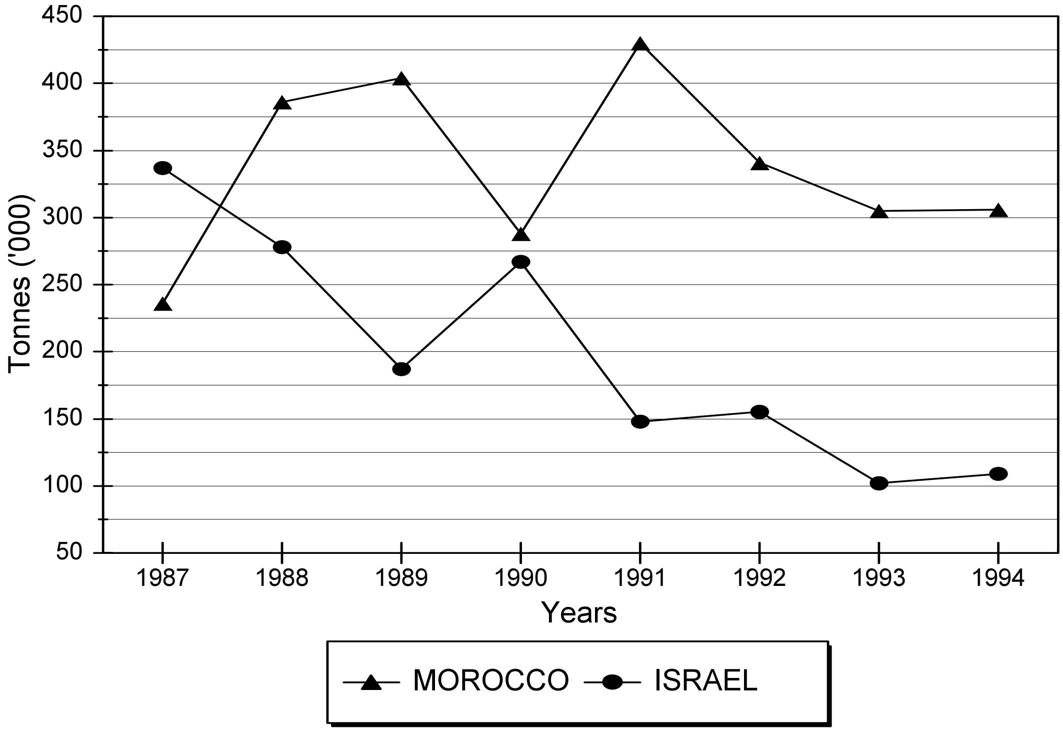

Figure 2. Orange market share (Western Europe) (Enkerlin and Mumford, 1995).

From 1987 to 1993 Israel dropped its export volume an average of 68 000 tonnes per year. In this same period Morocco increased its exports by an average of 68 000 tonnes per year and Spain by an average of 131 000 tonnes per year. It can be assumed that market and new EC regulations, the lack of comparative advantages of the Middle East countries, such as producing at lower costs, less pesticide residues, etc, gave Morocco and Spain a better position than Israel to compete for the European market.

Considering that historically citrus has represented 70% of the total fruit exports in Israel, this clear and significant decline in citrus exports has greatly affected the whole fruit export industry (Figure 3).

As a consequence, the planted citrus area decreased from 43 000 ha to less than 25 000 ha in 22 years (1975–1993) and the production shifted from exports to production for domestic fresh consumption and processing (Figure 4). For example, in 1995, some 330 000 tonnes (36%) were exported and 590 000 tonnes (64%) were sold in the local market for processing or as fresh fruit, compared to 60% for export and 40% for local market in the mid 70's.

Unemployment of agricultural workers in 1993 was 46% higher than the lowest unemployment figure of the past 6 years. Farmers have sold or used their land for urbanization or have rented their land for other uses while moving to the cities to work in other sectors of the industry.

Temperate fruit production is very important in Israel and its aim is mainly to supply the needs of the local market. The planted area and production have increased in proportion to the demographic growth in Israel. In 1992, 17 970 hectares of temperate fruits were under production in the highlands of Israel, producing 296 000 tonnes of fruit and a revenue of US $199 million which, for that year, was slightly higher than the whole citrus revenue (Table 2).

Subtropical and desert climate fruits are produced to supply the local market and for some exports, mainly to the European market. This production is, at present, the smallest of the fruit sectors in Israel. However, high profits obtained lately from exports of exotic fruits such as avocado, mango and persimmon has stimulated growers to increase significantly the planted area over the next 5 to 10 years. In 1992, 13,440 ha were under production in the subtropical and desert areas of Israel producing 209 100 tonnes of fruit and an income of US $190 million (Table 2).

According to the Rural Planning and Development Authority of the Ministry of Agriculture of Israel, taking 1993 as the base year, the planted area and production volume of all fruits in Israel will grow by 70% by the year 2020.

Fruits with export potential such as mango and avocado will increase more than 100%, whereas citrus is expected to grow by only 31%. For citrus this growth rate will only be enough to supply the present demand of the international markets, while the demand of the local population is expected to grow at a yearly rate of 1.13% and to reach 7.3 million inhabitants by the year 2020. This projection in planted surface shows, for citrus, that no perspectives are being considered to regain the lost share in the international markets in the next 25 years. The figures presented are clear indicators of the urgent need for alternatives to produce fruits that can compete better in the international markets that discriminate for "pesticide-free" and "pest-free" products.

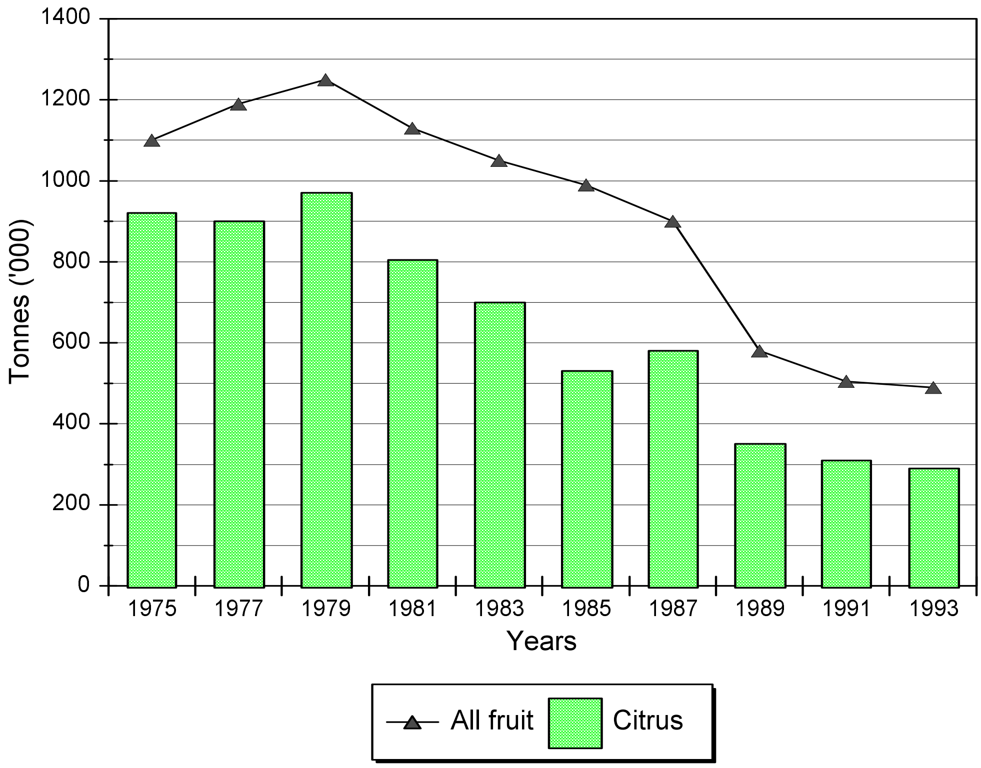

Figure 3. Fruit exports from Israel (1975 to 1993) (Enkerlin and Mumford, 1995).

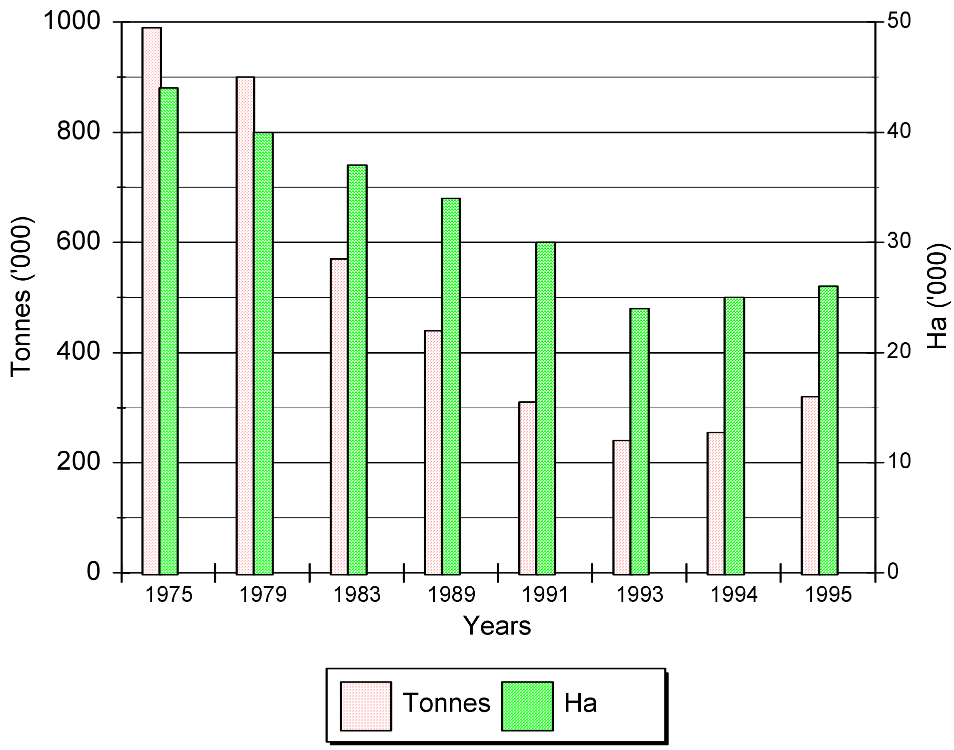

Figure 4. Israeli export citrus industry (Enkerlin and Mumford, 1995).

Table 2. Statistics of fruit production in Israel under a high technology production system in 1994 (Enkerlin and Mumford, 1995)

Crop	Area (ha)	Avg. Yield (tonne/ha)	Yield ('000 tonnes)	Value (US $mn)
Citrus:				
Shamouti	9660	32.5	314.0	49.8
Lates	4070	38.2	155.5	24.4
Grapefruit	7270	46.3	336.6	66.7
Other	7840	24.4	191.3	50.0
Subtotal	**28840**	**---**	**997.3**	**190.9**
Other fruit:				
Apple	4560	28.0	127.7	73.4
Pear	1150	17.9	20.6	17.4
Peach	3240	15.8	51.2	37.2
Apricot	790	15.8	12.5	8.6
Plum, quinceCherry	1750	16.3	28.5	16.5
Table grape	2790	18.4	51.3	35.1
Wine grape	1720	18.1	31.1	11.2
Banana	1680	52.7	88.5	34.5
Olive	13210	3.6	47.6	24.5
Almond	2690	1.1	3.0	3.9
Pecan nut	1000	1.2	1.2	2.8
Avocado	7590	10.6	80.5	56.5
Subtropical	2900	9.8	28.4	23.5
Date	1270	10.1	12.8	25.9
Others	1070	15.9	17.0	18.2
Subtotal	**47410**		**601.9**	**389.2**
Total	**76250**		**1599.2**	**580.1**

1.3.1.2. Fruit industry in Palestinian Territories

In Palestine, the fruit industry is relatively small but of great importance as a source of income and highly nutritive food for its population.

In the region of Gaza the main fruit crop is citrus with 5200 ha under high input production. Citrus production is for export and to supply the domestic market. Subtropical and desert climate fruits are grown on a very low scale, with dates (220 ha) being the most important crop. With the exception of grapes (700 ha) no other temperate fruit is grown commercially.

Table 3. Production and value of fruits considered to be medfly hosts in Jordan in 1996 (Enkerlin and Mumford, 1996)

Crop	**Area (ha)**	**Avg. Yield (tonnes/ha)**	**Price (US $/tonne)**	**Yield ('000 tonnes)**	**Value (US $mn)**
Citrus	5796.7	35.5	316.7	205.8	65.2
Stone	6927.9	4.8	865.0	33.3	28.8
Apple	4956.5	12.8	731.0	63.4	46.4
Pear	888.3	3.0	750.0	2.7	2.0
Quince	65.1	3.5	685.0	0.2	0.2
Fig	1371.7	4.9	550.0	6.7	3.7
Guava	185.8	21.1	514.0	3.9	2.0
Avocado	65.6	2.3	750.0	0.2	0.1
Papaya	98.5	1.5	600.0	0.1	0.1
Pomegranate	792.2	6.2	378.0	4.9	1.9
Date	189.4	5.2	800.0	1.0	0.8
Grape	12724.8	4.2	826.0	53.4	44.1
Total	**34062.5**	**---**	**---**	**375.7**	**195.2**

In the West Bank region fruit production is more diversified. About 2000 ha of citrus are grown. The temperate fruits grown in significant amounts are: apricots (550 ha), figs (2,300 ha), peaches (300 ha), pears (100 ha) and grapes (8200 ha).

With the exception of figs and grapes, most of the fruit must be shipped in from Israel to more than US $400 million, highly significant for a small economy. In 1994 the total fruit production was 278 000 tonnes (excluding olives and bananas) with revenues of US $78 million (Enkerlin and Mumford, 1995).

1.3.1.3. Fruit industry in Jordan

The fruit industry in Jordan, as in Israel, is highly diversified. It can also be divided into three different types of production: citrus, temperate fruits and subtropical/desert climate fruits. Around 40% of the fruit production in Jordan is highly technical farming (i.e. drip irrigation, high yielding varieties, modern pruning techniques, etc.) and 60% is low input farming. Most (2514 ha) and desert (12914 ha). Total yield was 375 700 tonnes producing revenues for US $195 million (Table 3).

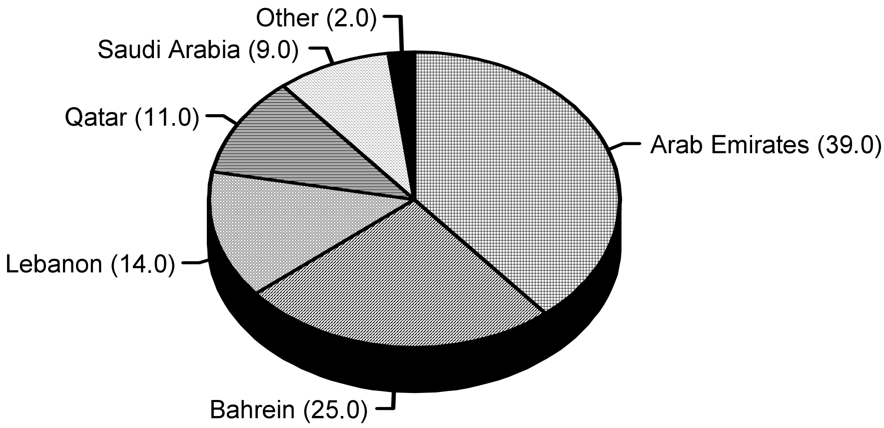

Figure 5. Jordan percentage exports to the Gulf countries (Enkerlin and Mumford, 1996).

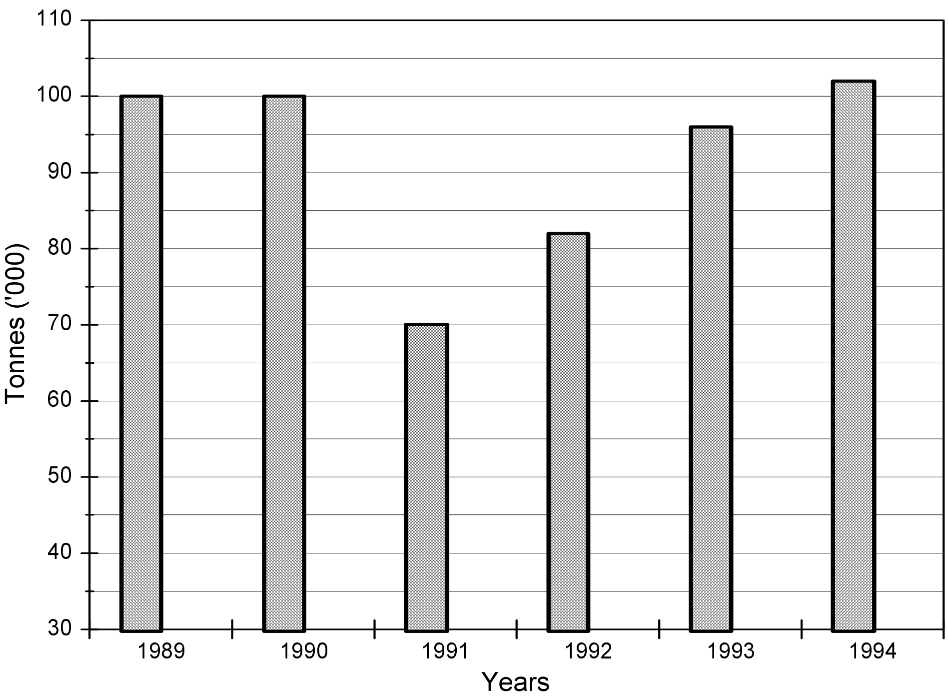

Figure 6. Jordan fruit exports (1989–1994) (Enkerlin and Mumford, 1996).

Table 4. Fruit commodities imported and exported from Jordan in 1994 (Enkerlin and Mumford, 1996)

Commodity	Imports Tonnes	Imports Value (US $million)	Exports Tonnes	Exports Value (US $million)	Trade Balance
Orange	37793.00	19.69	39830.00	20.75	1.06
Mandarin	1.00	0.0004	4209.00	1.50	1.50
Clementine	41.00	0.01	16143.00	5.75	5.74
Grapefruit	0.00	0.00	1271.00	0.35	0.35
Pomelo	0.00	0.00	1302.00	0.49	0.49
Peach	0.00	0.00	70.00	0.07	0.07
Apricot	0.00	0.00	2.00	0.002	0.00
Plum	0.00	0.00	52.00	0.03	0.03
Cherry	324.00	0.36	2.00	0.002	-0.36
Almond	0.00	0.00	20.00	0.02	0.02
Apple	3033.00	2.63	33.00	0.03	-2.60
Pear	587.00	0.23	0.00	0.00	-0.23
Loquat	0.00	0.54	0.00	0.00	-0.54
Pomegranate	0.00	0.00	1026.00	0.39	0.39
Fig	804.00	0.00	167.00	0.09	0.09
Grape	0.00	0.69	1391.00	1.19	0.50
Prickly pear	0.00	0.00	7.00	0.001	0.00
Date	2822.00	2.26	0.00	0.00	-2.26
Mango	136.00	0.13	0.00	0.00	-0.13
Khaki	1112.00	0.58	0.00	0.00	-0.58
Total	**46966.00**	**27.12**	**65525.00**	**30.67**	**3.54**

Fruit is produced for the domestic market but also for export mainly to the Gulf countries. Fruit production is not enough to supply the domestic market, which must be supplemented mainly with apples, oranges and dates from Syrian Arab Republic, Lebanon and Palestinian Territories. The main exports are citrus fruits (orange, clementine, mandarin and grape fruit), grapes and pomegranate, mainly to the Arab Emirates (39%), Bahrain (25%), Lebanon (14%) and Qatar (11%) (Figure 5 and Table 4).

After the Gulf war, fruit exports decreased in significant amounts due to boycotts suffered by Jordan from the traditional export countries. However, reconciliation has brought exports back to the levels they were before the war (Figure 6). In 1994, the total value of fruit imports was US $27 million compared to exports of US $30.7 million resulting in a positive trade balance of US $3.5 million (Table 4). Fruit production in Jordan is increasing rapidly. Each year the planted area of fruit grows on average 10 to 15%, mainly in the desert area. This is

enough to satisfy the present gap in the domestic demand, the yearly population growth of 2.5% and the increased demand from the neighbouring Gulf countries. This trend is different from Israel were the domestic demand is saturated and the traditional export markets are being lost and also different from the Palestinian Territories where little investment is being made in the fruit industry and, apart from citrus, fruits are being imported to supply the domestic demand.

The potential fruit exports from Jordan to fly free markets such as the USA or the Far East has been analysed. However, prices for fruit in the domestic market and in the traditional export markets are highly competitive against these other high value markets.

Also the high transport costs and the lack of modern storage and packing facilities limit this possibility.

1.3.1.4. Fruit industry in Lebanon

In the past in Lebanon agriculture was an essential sector in the economy, producing food and contributing substantially through exports of fruits and vegetables. For example, in the 60's Lebanon was considered one of the important worldwide producers of citrus and exported more than half of its production. Agriculture contributed 12% of the gross domestic product (GDP).

However, the agricultural sector and all other sectors in the economy were negatively affected by the civil conflict which started in 1975 and carried on for more than 15 years. During the war an important part of the economic infrastructure, industrial facilities and human resources were severely damaged or destroyed. The result was migration of human capital, market segmentation, escalation in inflation rate, depreciation of the Lebanese currency against all major currencies, emergence of large budget deficits and accumulation of a large public debt (Saade and Chatlla, 1991).

Profitability of the agricultural sector was significantly reduced due to high production costs as a result of poor production techniques (extension services were absent during the conflict) and damage to installations (e.g. irrigation) and facilities (e.g. roads) and inadequate marketing infrastructure (storage facilities and agro-industries) and practices. All these factors contributed to the present high risk associated with this sector which has suffered from lack of bank credits for investment and reactivation of the agricultural industry (Saade and Chatlla, 1991).

In 1991, about 44% of the total cultivated land was in fruit trees. Olives, grapes, citrus, apples and stone fruits are the main fruit crops in the country, forming about 90% of the fruit crop area. In that year, fruits considered to be medfly hosts (citrus, pome, stone and subtropical fruits) formed about 36% of the total area and around 57% of the total production. In 1996, these figures have decreased to 21.4% (ca. 22,000 ha) and 47.6% (ca. 503 000 MT) respectively, Table 5.

Table 5. Production and value of fruits considered to be Mediterranean fruit fly hosts in Lebanon in 1996 (Enkerlin, 1997)

Crop	Area (ha)	Avg. Yield (tonnes/ha)	Price (US $/ha)	Yield (tonnes) 1000	Value (US $mn)
Citrus:					
Navel	2195.0	38.6	198.0	84.7	16.8
Valencia	1600.0	35.5	334.7	56.8	19.0
Shamouti	927.0	39.6	223.5	36.7	8.2
Agrumes	348.0	26.3	217.8	9.2	2.0
Cimetier	381.0	32.7	122.8	12.5	1.5
Grapefruit	464.0	29.0	294.5	13.5	4.0
Clementine	1297.0	36.0	369.1	46.7	17.2
Mandarin	239.0	34.8	337.4	8.3	2.8
Subtotal	**7451.0**	**----**	**----**	**268.4**	**71.5**
Temperate:					
Apple	5176.0	20.2	514.4	104.6	53.8
Pear	2131.0	12.2	638.4	26.0	16.6
Apricot	1674.0	12.0	234.5	20.1	4.7
Peach	1192.0	14.5	686.6	17.3	11.9
Cherry	1514.0	10.0	548.7	15.1	8.3
Plum	935.0	24.0	380.0	22.4	8.5
Almond	754.0	7.0	539.3	5.3	2.8
Loquat	47.0	18.5	828.5	0.9	0.7
Subtotal	**13423.0**	**----**	**----**	**211.7**	**107.4**
Subtropical:					
Persimmon	615.0	37.2	323.4	22.9	7.4
Pomegranate	3.7	8.8	560.0	0.03	0.02
Guava	16.0	15.0	498.5	0.2	0.1
Figs	8.2	10.8	614.3	0.1	0.1
Subtotal	**642.9**	**----**	**----**	**23.2**	**7.6**
Total	**21516.9**	**----**	**----**	**503.2**	**186.5**

Citrus used to be, together with olives and grapes, the dominant fruit crop in Lebanon. At present, 7451 ha are planted (75% in the south coast, 20% in the north coast and the rest in Mount Lebanon) and produce around 268 000 tonnes per year and a revenue of about US $71.5 million. A number of factors have affected the predominant place that citrus had among the Lebanese crops before the civil conflict. Among the most important factors are

high production costs, low fruit quality and lack of market organisation. Lebanese citrus used to have a solid reputation among the traditional export market in the Persian Gulf but has been left now as a marginal export product. The Lebanese citrus market share was lost after 15 years of competition with larger volumes, more uniform quality and more competitive prices from Turkish, Egyptian, North African and, more recently, South African citrus. In 1993, around 25% (ca. 67 000 MT) of the total citrus production was exported, mainly to Saudi Arabia and Kuwait, down from more than 50% in the 60's (Saade, 1994). Because of the gradual loss of the export market the domestic market has often overflowed with citrus fruits, generating a significant fall in prices. Under these circumstances growers often have difficulties paying even the production costs. Another significant problem affecting profitability for the growers is the existence of large monopolies controlling the distribution of agricultural inputs such as fertilizers and pesticides. At the same time, there are some large wholesale traders controlling about 90% of total agricultural revenues. Thus growers pay high prices for the inputs and get lower prices for their output. These market imperfections have forced the growers to make savings in inputs such as pesticides, sacrificing fruit quality and yields. In the near future there is no clear sign of an important change in the trend of the citrus industry. The export crisis continues, the domestic demand is growing slowly and no credits are available to invest in infrastructure for fruit processing. Inefficient agricultural practices continue, there are limited economic resources and infrastructure to develop or improve the present technology and the Ministry of Agriculture has not yet reactivated the extension service (Saade, 1991).

Apples have been traditionally one of the most important crops in Lebanon. Its rapid increase started in the 50's on the basis of American varieties which were introduced in the mid 30's. However, in the past 10 to 15 years, planted area and production volumes have declined for many of the same reasons that were discussed for citrus. Production decreased from 130 000 MT in 1985 to 105 000 MT in 1996 produced on an area of 5176 ha. In 1996 the revenue obtained from this crop was around US $54 million, Table 2.5.

The high production costs are related to an inefficient use of some pesticides, high input costs, expensive cold-storage due to progressive increases in the cost of electricity and an inefficient transport system. The low prices are related to low quality of the fruit, the lack of export infrastructure and the excess domestic supply because of the contraction of the export markets.

In 1993, 32 924 MT of apples were exported (19% less than in 1992), mainly to Egypt (37%) and the rest to Saudi Arabia, Libya, Jordan and other Arab markets (Saade, 1994).

The future perspectives indicate a downward trend in apple production due to the high risks related to transport, low prices paid by wholesalers, competition with apples imported from Turkey and Syrian Arab Republic, by the same Lebanese exporters and strong competition from neighbouring countries (Saade, 1991).

In relation to pears, planted surface and production has been increasing despite the factors that affect production and commercialization. In Lebanon, 2131 ha of pear are planted producing 26 000 MT and a revenue of around US $17 million. One possible explanation for this increase in production is the fact that present production levels are not enough to satisfy the domestic demand and also that neighbouring countries (except for Syrian Arab Republic) are not particularly strong producers of this crop. In other words, for the time being, there is a certain degree of stability and security in the commercialization of this fruit.

Table 6. Production and value of fruits considered to be medfly hosts in Syrian Arab Republic in 1997, (The Annual Agricultural Statistical Abstract, 1994)

	Area (ha)			**Avg. Yield**		**Price**	**Yield ('000 Tonne)**			**Value**
Crop	**Non irr.**	**Irrigated**	**Total**	**Non irr.**	**Irrigated**	**(US $/tonne)**	**Non irr.**	**Irrigated**	**Total**	**(US $mn)**
Apples	25157	16573	41730	4.4	6.8	400	111.3	112.9	224.2	89.7
Cherries	12620	1899	14519	1.8	5.0	550	22.8	9.5	32.3	17.8
Orange	-	12100	12100	-	28.2	200	__	341.1	341.1	68.2
Apricots	1623	9505	11128	3.3	5.6	300	5.3	53.5	58.8	17.6
Figs	9768	954	10722	3.3	6.2	400	32.1	5.9	38.0	15.2
O. citrus	88	9849	9937	4.9	21.8	200	0.4	214.4	214.8	43.0
Pomegranate	796	5808	6604	8.2	9.5	300	6.5	54.9	61.4	18.4
Pear	2061	2929	4990	2.1	4.3	500	4.3	12.7	17.0	8.5
Peach	576	4182	4758	4.8	7.9	300	2.8	33.3	36.1	10.8
Plum	638	1866	2504	11.1	8.9	200	7.1	16.6	23.7	4.7
Quince	183	750	933	6.1	6.1	200	1.1	4.5	5.6	1.1
Loquats	65	64	129	7.6	10.9	400	0.2	0.5	0.7	0.3
Total	**53575**	**66479**	**120054**	**-**	**-**	**-**	**220.2**	**861.7**	**1082.0**	**295.3**

In 1993, 11,664 MT were exported, an increase of 21% over the 1992 amount, mainly to Saudi Arabia and Jordan (Saade, 1994).

Stone fruits are important crops in Lebanon, however, planted area and production volumes are significantly lower than for citrus and pome fruits. Apricot, peach and cherry are the most important stone fruits in Lebanon. A considerable amount of plum and almond are also grown. The overall planted area is around 6116 ha, producing 81 100 MT and revenues of US $36.9 million (Table 5). As for all other crops, stones fruits were severely affected by the civil conflict reducing their production levels by half. However, future perspectives look optimistic with a slightly increasing trend due to sustained domestic demand, better profits from these products and improvements in the production techniques (Saade, 1991).

Other fruits cultivated in Lebanon include traditional crops such as persimmon, pomegranate and figs, as well as subtropical fruits such as anonas, mango and papaya which in Lebanon are grown on a small scale and, with the exception of persimmon, play a secondary role in the Lebanese fruit industry. The total planted area is around 643 ha (95% persimmon), producing 23 200 MT of fruit and revenues for US $7.6 million, Table 5.

1.3.1.5. Fruit industry in the Syrian Arab Republic

Of the four countries and territories included in this study, Syrian Arab Republic is by far the largest (i.e. 185 000 km^2). Syrian Arab Republic has a variety of landscapes including: seacoast, mountains, forests, rolling hills, fertile valleys, plains and steppes. This allows for cultivation of a diversity of fruit crops. The total cultivated area with fruit crops considered to be Mediterranean fruit fly hosts is around 120 000 ha which is 2.5, 3.5, 5.4 and 6.2 times larger than Israel, Jordan, Lebanon and the Palestinian Territories, respectively. In Syrian Arab Republic, based on the planted area, the most important fruit crops (from the ones considered to be medfly hosts) are: apples (41 730 ha), stone fruits (32 909 ha), citrus (22 037 ha) and figs (10 722 ha) accounting for almost 90% of the planted surface. In general yields of the most important fruit crops are considered low compared to the other countries in the region. For example, Israel in 48 500 ha produces 1.4 million metric tonnes and Lebanon in 21 500 ha produces 503 000 metric tonnes compared to Syrian Arab Republic which produces in

Table 7. Trade balance of agricultural commodities considered to be medfly hosts in Syrian Arab Republic in 1994 (The Annual Agricultural Statistical Abstract, 1994)

Crop	**Yield ('000 tonnes)**	**Imports ('000 tonnes)**	**Exports ('000 tonnes)**	**T. supply ('000 tonnes)**
Citrus	619.0	6.0	3.0	622.0
Apple	224.0	0.0	3.0	221.0
Pomegranate	61.0	0.0	1.0	60.0
Apricot	59.0	0.0	5.0	53.0
Fig	38.0	0.0	1.0	37.0
Plum + other	37.0	0.0	7.0	30.0
Peach	36.0	0.0	3.0	33.0
Cherry	32.0	0.0	7.0	25.0
Pear	17.0	0.0	3.0	14.0
Quince	6.0	0.0	0.2	5.8
Total	**1,129.0**	**6.0**	**33.2**	**1100.8**

120 000 ha around 1.1 million metric tonnes. In Syrian Arab Republic 45% of the total area bearing fruit is considered low input production with no irrigation. The remaining 55% is production with irrigation with much better yields but still low compared to those other countries. The irrigated fruit crops produce in 55% of the land bearing fruit crops, 80% of the total production (Table 6).

Fruit production in Syrian Arab Republic is strongly oriented towards the domestic market. Syrian Arab Republic produces enough fruit to satisfy the domestic needs which is ca. 68 kg of fruit production per capita per year. Fruit imports is at very low scale and the most frequently imported fruit is citrus. For example, in 1994, 6000 MT of citrus were imported. Also the export fruit industry in Syrian Arab Republic operates at very low volumes. For example, in 1994, 33 200 MT (2.9% of the total production in that year) of fruits were exported with a value of US $8 million (Table 7). Fruits considered to be medfly hosts in Syrian Arab Republic generate US $295 million per calendar year. The fruit industry is considered an important factor of the Syrian Arab Republic economy. The agricultural sector generates around 21% of the gross domestic product (GDP). It is the most important GDP source after mining and manufacturing (The Annual Agricultural Statistical Abstract, 1994). Nevertheless, the fruit industry could be made much more productive with improved agricultural practices such as the use of the SIT for medfly control.

1.3.2. Organization and commercialization within the region

Fruit growers in Israel have a high level of organization and technical prowess. They are affiliated by law to two big centralized organizations: the Citrus Marketing Board (CMB) and the Fruit Board of Israel. These two organizations link the fruit growers with the official sector which, through the Ministry of Agriculture, regulates certain aspects of fruit production and commercialization and provides technical assistance and financial support (subsidy) to the growers.

Before 1991, in the case of citrus production, which was normally export oriented, marketing of citrus was controlled by the official sector. Farmers gave the fruit to the government on

concession. After the fruit was sold and costs of production and commercialization were cut down, returns were refunded to the farmer. On many occasions farmers had to pay the Board for negative returns. This centralized controlled production-marketing system was one of the contributing factors of the decline of the export fruit industry. Since 1991, to encourage citrus fruit production, the system has been modified to a multi-channel marketing type organization where the farmers agree with private companies a farm gate price which is normally beneficial to both parties. As a result, in 1994 and 1995 a slight increase in production volumes and revenues was observed (Figure 4). For exports of other fruit such as avocado, grapes, mango and persimmon the government still controls the marketing through state enterprises such as Agresco and Carmel.

The situation in the Palestinian Territories is radically different from that in Israel. In Gaza and the West Bank (Judea and Samaria) no grower organizations exist. Farmers own the land and look after it individually. All the production-marketing system is controlled by the Palestinian Authorities. Farmers give the fruit to the Authorities on concession. No private firms are involved (Enkerlin and Mumford, 1995).

In Jordan, a few small grower organizations exist in the form of unions and cooperatives. Jordan has a free market economy and growers have the opportunity to work individually and sell their products to the best buyer. Under this system an important number of profitable private companies have been developed.

The government, through the Agricultural Marketing Organization (AMO), supports the growers by improving the efficiency of the marketing system, by identifying demand of imports into neighbouring Gulf and EU markets. Also the Department of Postharvest Technology Development provides know how on packing, grading, etc to ensure compliance with the grades and standards of foreign markets. Export license are given by AMO to any grower that can meet the minimum volumes and quality standards. Growers pay a fee to AMO for the service.

AMO is chaired by the Minister of Agriculture and grants from GTZ and US AID are available for market development.

In Lebanon among the key factors affecting the fruit industry is the lack of fruit growers organizations in any form (e.g. associations, committees, unions, etc). The high production costs due to inefficient agricultural practices and commercialization and the fact that some domestic and export products are dominated by monopolies can be attributed in part to the absence of any type of fruit growers organization. Growers deal individually with retailers to sell their products and with importers and distributors of agricultural supplies to purchase their inputs. Frequently growers are not paid according to the real value of their products and production costs. Often a large proportion of the profit is for the retailers.

In addition to this, growers have very limited support or guidance from the Ministry of Agriculture in extension services and in general from the government in providing clear agricultural policies or intervention for a price support system or control over the imports, etc (Saade and Chatlla, 1991).

In Lebanon the role of public and private institutions in agriculture is as follows: The National Council for Scientific Research (NCSR) is a public autonomous institution affiliated with the

Prime Minister's office. As a consulting body of the government, NCSR is responsible for developing the general lines for national scientific policies aiming for development of scientific research and efficiently utilize national scientific resources. In implementing its mandate, the NCSR promotes, supports, coordinates and conducts research of importance for social and economic development.

Research in plant protection and in general in techniques to improve production for field crops, vegetables and fruit trees is done through the Agricultural Research Institute (ARI). ARI is a semi-autonomous national research organization directly responsible to the Minister of Agriculture. In addition to research, ARI also provides extension service as part of the technology transfer process.

The university system also plays a role in the agricultural research being done in Lebanon. These universities are: the Faculty of Agricultural and Food Sciences (FAFS) of the American University of Beirut (AUB) through its crop production and protection Department and the Faculty of Agricultural Sciences of the Lebanese University (FASLU). FASLU in the absence of extension service, has been active during 1991 and 1992 in training extensionists.

ARI and the universities collaborate together in research and training, jointly organizing workshops. More efforts to improve this collaboration are needed.

NCSR supports agricultural research at ARI, FAFS and FASLU by providing funds and personnel. During the civil conflict, NCSR support declined considerably. From 36 projects supported in the 1975–1984 period it fell to 17 projects in the 1984–1992 period. However, the NCSR is reactivating its role in support to research in the country. A new Board of Directors for NCSR was named by the Council of Ministers in January 1993 and it is expected that the financial contribution of NCSR to support agriculture will be increased in the coming years.

One of the key strategies of ARI is to create and expand its linkages with other national agricultural research systems, regional and international organizations. For the period 1993–1996, US $6 million have been contributed by UNDP and FAO to support a number of agricultural projects in Lebanon and other projects for support from other donors (i.e. World Bank, European Community, etc.) are in the pipeline. At present ARI and the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture are conducting a research project aimed to a pilot implementation of the Sterile Insect Technique (SIT) to control the Mediterranean fruit fly in Lebanon. The area-wide implementation of this technique would have an immediate positive impact in the Lebanese fruit industry.

During the conflict ARI lost an important part of its human resources and physical infrastructure thus its capacity to operate was reduced considerably. At present ARI is in a rehabilitation process.

Private companies of importers and distributors of agricultural supplies (mainly agrochemicals) have played a vital role in the Lebanese agriculture particularly during the war by filling the gap left by the Minister of Agriculture. These companies are grouped in an association named ASSPLANT. The Minister of Agriculture in collaboration with ASSPLANT formed the "Plant Protection Product Committee" whose members are from both the public sector and private sector. The committee decides on the major issues concerning agrochemicals in Lebanon.

The private sector in Lebanon has been engaged in large scale, agriculture since the early 20's. One of the pioneer companies of agricultural development in Lebanon and the rest of the Near East is Comptoir Agricole du Levant (CAL). CAL operates in Lebanon, Syrian Arab Republic, Jordan and Saudi Arabia through a group of ten companies serving the needs of various sectors and markets. CAL group is involved at the present time in the following fields:

(1) Agribusiness (agricultural production)
(2) Agro industry
(3) Engineering and contracting
(4) Services (shipping, clearing and insurance)

In addition to securing farmers needs of all types of inputs, CAL has its own spraying teams and acts on contracts with farmers, provides credit facilities, a reliable channel for the sales of their crops and shipping, chartering ships or booking space on part charters or liner vessels (CAL, 1995).

The private sector has also been actively involved in agricultural research through the Lebanese Centre for Agricultural Research and Studies (CREAL). CREAL is a Scientific Institution devoted to agriculture and rural development as well as environment preservation. Its mission is to study the Lebanese agriculture sector and to act for its development. It covers global and specific aspects of Lebanese agriculture and the output can be used by students, researchers and authorities at local and international levels. CREAL undertakes consultancy activities for local administrations and international organisations. CREAL has been for the past ten years the only source of agricultural statistics in Lebanon. Its data are officially adopted by the Ministry of Agriculture and FAO (CREAL, 1996).

Fruit production and commercialisation in Syrian Arab Republic is controlled by the government. The government has a strong extension service network which is used to provide technical advice to farmers and is responsible for the technology transfer process. Every village in the rural areas has its units of agricultural agents. In 1993, the number of active agricultural engineers registered in unions and distributed for extension service in the 13 districts of Syrian Arab Republic was around 14 000. A good example of the extension service in Syrian Arab Republic is the case of the codling moth pheromone traps in the province of Sweida. This technology was transferred by extension agents to apple growers who managed to reduce insecticide sprays against codling moth from an average 6.5 per season to 2 by timing the sprays with the aid of male specific pheromone traps.

Also farmers have an extensive agricultural structure. There is a central farmers league (federation) which is subdivided into provinces farmers leagues (federations) and farmers cooperatives in villages. There are 733 020 member farmers organized in 4980 cooperatives and 61 federations (The Annual Agricultural Statistical Abstract, 1994). A strong farmers organizational structure together with an efficient extension service network are two important conditions for the successful implementation and operation of area-wide insect control programs.

1.3.3. Medfly problem in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic

A common problem for the fruit industry of the four countries and territories is the Mediterranean fruit fly *(C. capitata)*. This insect is a major pest in all the Mediterranean basin

countries. It infests most cultivated and wild soft skin fruits and some vegetables are also considered potential hosts. In Israel and the Palestinian Territories damage to fruit normally occurs from April to November when medfly populations become more abundant. From December to March, which is the winter season, populations drop in some cases to undetectable levels and no apparent damage is caused. This natural reduction of medfly populations can be an important advantage for a suppression or eradication program using either baits or the SIT. In Jordan, medfly populations also decrease during the winter months. However, availability of fruit and a suitable climate, especially in the Jordan Valley, allow for medfly infestations during the whole year.

It has been estimated that if this pest was left without control the total direct and indirect damage for Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic would be about US $579 mn per year which is more than half (53%) the total annual revenue produced by fruits considered to be medfly hosts in these countries (Enkerlin and Mumford, 1996; Enkerlin, 1997). In areas where no control methods are applied, reports by senior entomologists and experienced field technicians of the Ministry of Agriculture in the Middle East countries, indicate up to 100% loss for the most susceptible varieties of peaches, apricots, citrus, guavas, figs and apples.

In Israel, citrus growers first initiated a centrally organized campaigned for medfly control. The Citrus Marketing Board of Israel (CMBI) was given legal responsibilities for conducting all medfly control operations. This same law was enforced in 1992 for all other fruits considered to be medfly hosts. The Biocontrol Institute of the CMB is responsible for operating the program. A Pest Control Committee of the Plant Protection and Inspection Service of the Ministry of Agriculture provides legal and technical support and collaborates with the Biocontrol Institute in the control of the medfly.

The CMB obtains financial resources by charging a levy per tonne of fruit which is used to pay 50% of the program costs. The government partially subsidizes the operations by providing funds to cover the other half.

Through this system, the medfly is effectively controlled by means of an area-wide supervised control program. The basic components of this program are: monitoring using trimedlure in Modified Steiner traps, and partial cover aerial bait sprays (malathion ULVC 96% & hydrolysate protein). As a result, direct damage to fruit is not significant at present (Rossler, 1989).

For countries with an efficient medfly control operation and a well developed fruit industry, the main economic loss is caused by the enforcement of stringent quarantine measures by medfly free countries that prohibit imports of fruit commodities unless a post harvest treatment is applied. This limits the development and growth of export oriented fruit industries. For example, as has been shown, for the last 25 years Israel's export fruit industry has depended on citrus exports to Western Europe. However, Israel's citrus export market has been gradually lost to competing citrus producers. Diversification of export fruit commodities and export markets, which could be seen as alternatives to reactivate the export industry, has not been feasible due to the quarantine restrictions imposed by potential markets such as Japan and South Korea. In the Palestinian Territories, in Gaza, the government is responsible for all activities related to medfly control with no grower participation, while in the West Bank growers collaborate with the government in field operations. Part of the expenses are paid by the government and part by the growers through levies.

Table 8. Damage, despite control, caused by the Mediterranean fruit fly on crops in Israel and Palestinian Territories in 1995 (Enkerlin and Mumford, 1995)

Crop	Damage (%)	Production (tonnes)	Loss (tonnes)	Price (US $/tonne)	Loss (US $'000)
			Israel		
Orange	0.02	400080	80	140	11.2
Grapefruit	0.02	410082	82	140	11.5
Easy Peelers	0.02	86617	17	200	3.5
Peach	0.10	62462	62	400	25.0
Apricot	0.10	13113	13	400	5.2
Apple	0.05	138569	69	258	17.9
Pear	0.05	29815	15	542	8.1
Plum	0.10	30531	31	308	9.4
Persimmon	0.20	16433	33	333	10.9
Grapes	0.02	55211	11	500	5.5
Mango	0.20	29559	59	966	57.1
Guava	1.00	3030	30	333	10.1
Nectarine	0.10	18118	18	400	7.2
Total	**---**	**---**	**---**	**---**	**182.6**
			Palestinian Territories		
Citrus	0.40	177000	708	177	125.3
Other	2.00	101300	2026	462	936.0
Total	**---**	**---**	**---**	**---**	**1061.3**

An area-wide supervised control program against the medfly is in operation only for citrus, their main fruit crop. In this case, bait sprays are done by ground, and monitoring using the Modified Steiner Trap is only done in Gaza. Having less efficient operations, damage is higher and reaches economic levels particularly in non citrus fruits. Damage in citrus is on average 0.4%, which is higher than in Israel but is still economically acceptable. However, the average yearly damage in other fruits ranges from 2 to 6% depending on the environmental conditions (Table 8) (Enkerlin and Mumford, 1995).

In Jordan, conventional scheduled spraying is used to control the medfly. There is no area-wide coordinated effort to control this pest. The Ministry of Agriculture through its Extension Department provides the growers with information on medfly biology, timing for insecticide spraying and type of insecticides for medfly control. This information has been produced by the National Centre for Agricultural Research and Technology Transfer (NCARTT) which operates in coordination with the Ministry of Agriculture but with complete autonomy. Considering the perspectives for an area-wide approach for medfly control, the NCARTT has started field trials in various parts of the country to collect information on population dynamics, alternative lures for trapping and susceptibility of the different fruit crop varieties.

Table 9. Damage, despite control, caused by the Mediterranean fruit fly in Jordan in 1996 (Enkerlin and Mumford, 1996)

Crop	Damage (%)	Production (tonnes)	Loss (tonnes)	Price (US $/tonne)	Loss (US $mn)
Citrus	39	205800	80262	317	25.44
Stone	47	33300	15651	865	13.54
Apple	21	63400	13314	731	9.73
Pear	18	2700	486	750	0.36
Quince	1	200	2	685	0.00
Fig	55	6700	3685	550	2.03
Guava	70	3900	2730	514	1.40
Pomegranate	1	4900	49	378	0.02
Date	2	1000	20	800	0.02
Grape	7	53400	3738	826	3.09
Other	7	300	21	350	0.01
Total	**---**	**375600**	**119958**		**55.64**

In Jordan, medfly produces a significant amount of damage in fruit crops due to the low efficiency of the control method applied. In high input orchards organophosphates (dimethoate and lorsban) are sprayed 5 to 7 times during the fruiting season. In low input orchards 2 or 3 sprays are applied per season. The most susceptible late varieties of fruits are heavily infested. For example, late varieties of apple, mandarin and clementine, in the low input management orchards, often get 70% damage. In peach, infestations are even higher, reaching 100% damage (Abdel-Jabbar, 1994). By consensus of senior entomologists and experienced field technicians of the Ministry of Agriculture, country wide, the average damage has been estimated at 29% using the conventional control methods (Table 9).

In Lebanon the medfly attacks fruit crops from March to November and the populations tend to disappear during December to February because of the cold winter weather and reduced availability of susceptible fruits (Table 10).

It infests citrus, pome, stone and subtropical fruits. There is no area-wide coordinated effort to monitor and control medfly in Lebanon. No extension service is provided by the Ministry of Agriculture and medfly control is done using the products and techniques recommended by the pesticide companies which also provide spraying services to the farmers. At present, medfly is controlled by conventional calendar cover sprays using mainly broad spectrum organophosphate insecticides such as dimethoate and malathion. The average farmer sprays 2

Table 10. Damage, despite control, caused by the Mediterranean fruit fly on crops in Lebanon in 1996 (Enkerlin and Mumford, 1995)

Crop	Damage (%)	Production (tonnes)	Loss (tonnes)	Price (US $/tonne)	Loss (US $mn)
Orange	18	200000	36000	237.6	8.55
Grapefruit	25	13500	3375	294.5	0.99
Clementine	20	46700	9340	369.1	3.45
Mandarin	20	8300	1660	337.4	0.56
Apple	3	104600	3138	514.4	1.61
Pear	5	26000	1300	638.4	0.83
Apricot	0	20100	0	234.5	0.00
Peach	3	17300	519	686.6	0.36
Cherry	0	15100	0	548.7	0.00
Plum	0	22400	0	380 .0	0.00
Almond	0	5300	0	539.3	0.00
Loquat	3	900	27	828.5	0.02
Persimmon	0	22900	0	323.4	0.00
Pomegranate	0	30	0	560.0	0.00
Guava	30	200	60	498.5	0.03
Figs	15	100	15	614.3	0.01
Total	**----**	**503430**	**55434**	**----**	**16.42**

Table 11. Damage, despite control, caused by the Mediterranean fruit fly on crops in Syrian Arab Republic Arab Republic in 1997

Crop	Damage[1] (%)	Production ('000 tonnes)	Loss ('000 tonnes)	Price (US $/tonne)	Loss (US $mn)
Orange	29.7	341.1	101.3	200.0	20.3
O. citrus	29.5	214.9	63.4	200.0	12.7
Fig	22.6	38.0	8.5	400.0	3.4
Apricot	7.9	58.8	4.6	300.0	1.4
Peach	6.8	27.9	1.9	300.0	0.6
Apple	0.4	224.2	0.9	400.0	0.4
Pear	0.0	17.0	0.0	500.0	0.0
Plum	0.0	23.7	0.0	200.0	0.0
Pomegranate	0.0	61.5	0.0	300.0	0.0
Cherry	0.0	32.3	0.0	550.0	0.0
Quince	0.0	5.7	0.0	200.0	0.0
Loquat	0.0	0.7	0.0	400.0	0.0
Total	**-**	**1045.8**	**180.6**	**-**	**38.8**

[1]Weighted average of different damage levels from different regions in Syrian Arab Republic Arab Republic.

or 3 times per season to control pests such as mealy bugs, scales (e.g. California red scale), white flies, leafminer and medfly. Farmers that grow late varieties of fruit crops such as Valencia orange tend to spray 1 or 2 times more specifically to avoid medfly damage.

At present, the Minister of Agriculture, through its Agriculture Research Institute (ARI), is conducting, in collaboration with the Joint FAO/IAEA Division, a research project aimed to apply, in the near future, the Sterile Insect Technique (SIT) to control medfly in Lebanon. A number of Jackson traps baited with trimedlure have been placed strategically in ARI's research stations in the south and north cost of Lebanon. Fly captures have been recorded for months and preliminary results on population fluctuation and abundance have been produced. Also, in ARI's research station at Fanar laboratories have been adapted into a medfly rearing facility. During the present year production of sterile flies should start and reach high enough numbers for the implementation of a sterile male release pilot test in citrus orchards.

In the Syrian Arab Republic, organophosphates are sprayed under a calendar basis to control a number of insect pests including medfly. Farmers spray an average rate of two sprays per season. The direct damage caused by medfly on fruit production despite control efforts is different among the fruit host species (Table 11). Apples and pears grown in the Southern part of the country escape damage due to low temperatures during winter and orchard isolation. This same fruits show low levels of damage (i.e. 1.3%) in the Northern Coast where they are grown at lower altitudes. In stone fruits (i.e. apricots, peaches, plums and cherries), which are also grown in the highlands, medfly damage doesn't exceed 10%. However, fruit hosts (i.e. figs and citrus) grown in warmer climate at lower altitudes show significant levels of damage despite control. The average damage in figs, oranges and other citrus is 22.6, 29.7 and 29.5%, respectively. It is important to make clear that in oranges and other citrus the damage figure is without chemical control. Four years ago the Syrian Arab Republic government banned the use of insecticides in citrus orchards. Since then, medfly damage levels have been increasing and in 1997 the reported average damage was near 30%.

Data indicate that efforts to control medfly in citrus orchards by using the classical biocontrol method have failed.

Overall in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic, despite the control measures being applied, the direct damage (i.e. damage by pest and spray costs) has been estimated at US $125.7 million per year (78% occurring in Jordan and Syrian Arab Republic) and the indirect damage (environmental impact and market loss) at US $166 million per year. The total damage in the region amounts to US $298 million per year compared to revenues for US $1.1 billion.

2. DESCRIPTION OF TECHNIQUES FOR AREA-WIDE MEDFLY CONTROL

2.1. Medfly control options

For medfly control in Israel, Palestinian Territories, Jordan, Lebanon and Syrian Arab Republic three alternative program options are compared: population suppression using bait sprays (BAIT-SUPP), population suppression using massive releases of sterile males (SIT-SUPP) and population eradication using massive releases of sterile males (SIT-ERAD). For each option a technical plan has been prepared that includes intensity, frequency and timing in the application of sampling (trapping and fruit gathering), control (bait sprays and sterile male releases) and post control (quarantine and emergency capacity) techniques. For the application of the SIT-SUPP and SIT-ERAD control options the area has been divided into 7 zones according to geographical and topographical features, continuity of hosts and national boundaries for quarantine purposes. For each zone the process from initiation of pre-eradication activities until verification of fly-free area status will require at least 4 years.

2.1.1. Regional suppression using bait sprays (BAIT-SUPP)

In the case of Israel, a national area-wide BAIT-SUPP program is at present being successfully operated in fruit orchards. The program consists basically of a very well established trapping network using Modified Steiner traps baited with trimedlure. Traps are serviced weekly and Medfly captures are used as an action threshold to start repeated aerial bait sprays of malathion mixed with hydrolysed protein.

However, an exotic fruit fly trapping network is still lacking and must be established to avoid risks of alien fruit fly introductions (e.g. *Ceratitis rosa*, *Bactrocera zonata*, *Rhagoletis pomonella*, etc.) and potential outbreaks. In this study a trapping network of this nature has been included in the technical plan and the costs of its operation represent an important share of the total trapping costs.

In the Palestinian Territories a supervised bait spray program is also under operation but only for citrus, which is their main crop. The technical plan in this case includes an area-wide BAIT-SUPP program for all fruits considered to be medfly hosts as well as an exotic fruit fly trapping network.

The effective application of this control option in Israel and the Palestinian Territories reduces populations by 99% which is enough to keep damage under quality thresholds when fruit is produced for domestic markets or export markets not requiring fly-free status. Access to high value markets in Japan, USA or Korea are sometimes feasible by applying post harvest treatments to eliminate any risk of pest introduction. These treatments are costly and are not available for many important fruit crops. One other disadvantage is the substantial and permanent use of malathion which affects the levels of pesticide residues in fruit, induces secondary pest outbreaks by killing natural enemies and limits the use of beneficial insects in area-wide IPM (integrated pest management) programmes for other pests.

Fruits produced under this control option have limited access to discriminating "pesticide-free" and "pest-free" markets.

Considering that the working zones for this control option only include commercial orchards, that no major infrastructure is needed and also that no massive amounts of sterile flies are

required, full implementation of this control option can be achieved in the whole region (Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic), in the second year.

If suppression is achieved in the second year, as presented in the technical plan, benefits for all the region can be produced in the same year.

2.1.2. Regional suppression using SIT (SIT-SUPP)

This control option is based mainly on weekly or fortnightly releases of sterile flies at densities of 750 flies/ha in fruit orchards and lower densities (500 flies/ha) in urban areas. In the first and second years (pre-suppression phase) three bait spray applications are used to suppressed medfly populations prior to the release of sterile males. From year three or four (suppression phase) depending on the working zone, suppression status is maintained by spraying twice per year and by constantly releasing relatively low numbers of sterile males (as compared with the eradication phase of the SIT-ERAD option, up to 1500 flies/ha). Even with the medfly population at relatively low levels, multiple and dispersed outbreaks are likely. To account for this an emergency plan is considered as part of the control strategy for this option.

No additional quarantine activities are enforced, and trapping effort is low. The main cost is the permanent use of sterile males. The total amount of sterile males required per week for the region (Israel, Palestinian Territories, Lebanon and Syrian Arab Republic) is 436 million (22 666 million per year) at a cost (purchase plus release) of US $215.8 million compared to a cost of US $318 million per year if bait sprays were used. No major capital investment is required if sterile males are purchased abroad rather than produced in a local factory.

This control option is more extensive than BAIT-SUPP. Working zones include commercial orchards, urban areas and other areas. Considering that the basic tool for suppression is sterile flies, the infrastructure to be developed is mainly for packing and holding the sterile flies. Training and information for farmers and the general public is also needed, to describe the new techniques to be used. These activities are part of the pre-suppression phase and are a prerequisite for full implementation of this control option.

This is a gradual process. During the first year pre-suppression activities would be enforced in the southern and central part of the region and in the mean time in the northern parts medfly would be controlled using the present methods. By year 2, suppression actions would be enforced in the southern and central parts while pre-suppression starts in the northern areas. By year 4, full suppression would be achieved in the whole region.

As in bait suppression, access to fly-free export markets can be achieved only by using post harvest treatments. The smaller amount of pesticide used can be considered as a comparative advantage in relation to BAIT-SUPP. Malathion residues on fruit would be reduced significantly and negligible damage to beneficial insects would occur. Biological control is compatible with this control option.

2.1.3. Regional eradication using (SIT-ERAD)

Sampling and control methods would be used extensively and intensively during the first six to seven years (eradication phase). Two or three bait spray applications would be used to reduce populations to achieve maximum efficiency from SIT, followed by weekly massive

releases of sterile males (500 to 1500/ha) resulting in effective eradication in a short time. 80% of the total program costs apply to this phase. Once eradication has been achieved in the whole region, from year eight (post-eradication and fly-free phase) the main activities are the operation of a sensitive trapping network and of a national and international quarantine. During the fly-free period, costs fall to 76% of the initial level, to US $11 million/year, which is the lowest of the three control options. As in SIT-SUPP, purchasing sterile males, rather than establishing a factory, would significantly reduce capital costs.

Eradication of the medfly would eliminate direct damage, no post harvest treatments would be required and access to high value export markets would be a possibility. Residues of malathion, used for medfly control, would be eliminated and area-wide IPM programs using biological agents against other pests could be implemented with no risk of damage due to malathion drift. Also damage to beehives would be avoided so no reduction in honey yield and fruit yield would be produced. Creating or enhancing the quarantine infrastructure against other quarantine pests and eliminating the pest from fruit trees in backyards in rural and urban areas are also comparative benefits produced by this control option.

In order to accurately estimate the project costs a detailed technical plan for each control option by zone and by year was prepared.

Table 12 is a feasibility table where the control options are listed vertically and the various criteria that might be used to assess feasibility are listed across the top of the table (Norton and Mumford, 1993). The table allows for an objective and practical comparison of the pros and cons of each of the control option discussed above.

2.1.3.1. General strategy for the SIT-ERAD control option

The general plan for SIT eradication of medfly has been presented by a group of IAEA technical experts (IAEA, 1997).

Table 12. Pros and cons of the three alternative control options

Control options	Technically possible	Insecticide Use	Central infrastructure	Economically desirable		Social acceptability	Risk Acceptability
				Short term	Long term		
Bait Suppression	Yes	+++	+	++	+	+	++
SIT Suppression	Yes	+	+++	+++	++	+++	+++
SIT Eradication	Yes	+	+++	+	+++	+++	+

+ (slight), ++ (moderate), +++ (considerable)

To conduct eradication simultaneously in the whole region (Israel, Palestinian Territories, Jordan and Lebanon) would be economically unfeasible because a huge amount of sterile flies, capital and operational inputs would be required (i.e. fly factory, packing and holding facilities, quarantine infrastructure). In relation to flies, 1132 million high quality sterile adult flies per week (58 873 million/year) would be required during the eradication phase and 1132 million per fortnight (29 436 million/year) during the post-eradication phase to eliminate the wild medfly populations. It is unlikely, at this stage, that a private firm would be willing to

Table 13. Estimated project working zones (sq km). (IAEA, 1997)

Country	Zone	Urban Areas	Commercial Orchards	Other Areas	Total
	I	10.2	5.7	60.0	75.9
Israel	II	520.0	215.0	1185.0	1920.0
	III	800.0	197.0	40.0	1037.0
	IV	342.0	66.9	118.0	526.9
	Subtotal	**1672.2**	**484.6**	**1403.0**	**3559.8**
Palestinian Territories	I	760.0	129.6	970.0	1859.6
	II	350.0	66.4	100.0	516.4
	Subtotal	**1110.0**	**196.0**	**1070.0**	**2376.0**
	I	125.0	30.0	530.0	685.0
Jordan	II	300.0	60.0	600.0	960.0
	III	425.0	101.0	1120.0	1646.0
	IV	450.0	150.0	2295.0	2895.0
	Subtotal	**1300.0**	**341.0**	**4545.0**	**6186.0**
Lebanon	IV	331.5	71.2	463.5	866.2
	V	700.0	144.0	950.0	1794.0
	Subtotal	**1031.5**	**215.2**	**1413.5**	**2660.2**
Syrian Arab Republic	V	200.0	1156.0	7000.0	8356.0
	VI	250.0	1500.0	12000.0	13750.0
	VII	50.0	140.0	3960.0	4150.0
	Subtotal	**500.0**	**2796.0**	**22960.0**	**26256.0**
	Total	**5613.7**	**4032.8**	**31391.5**	**41038.2**

invest the large amount of capital necessary to establish a factory with capacity for > 1 billion sterile flies per week, with so much uncertainty over the potential demand from sterile fly consumers after eradication has been achieved in the region. However, if eradication is done by zones, dividing the region into smaller areas that would require smaller amounts of sterile flies (300 to 500 million/wk), demand would be for a longer period of time or, for suppression, continue indefinitely, greatly increasing the attraction for private capital.

Taking this into consideration, a 14-year eradication project was prepared for the whole Middle East region dividing the region into seven zones of different dimensions (Figure 7).

GOALS	PROJECT PHASES	YEAR	ZONES
Declare zone VII medfly free by year 9	Fly-Free Zone (FFZ)	9	VII
	Post eradication (POST)	8	
	Eradication (ERAD)	7	
	Pre-eradication (PRE)	6	
Declare zone VI medfly free by year 8	FFZ	8	VI
	POST	7	
	ERAD	6	
	PRE	5	
Declare zone V medfly free by year 7	FFZ	7	V
	POST	6	
	ERAD	5	
	PRE	4	
Declare zone IV medfly free by year 6	FFZ	6	IV
	POST	5	
	ERAD	4	
	PRE	3	
Declare zone III medfly free by year 5	FFZ	5	III
	POST	4	
	ERAD	3	
	PRE	2	
Declare zone II medfly free by year 4	FFZ	4	II
	POST	3	
	ERAD	2	
	PRE	1	
Declare zones I medfly free by year 3	FFZ	3	I
	POST	2	
	ERAD	1	
	PRE	1	

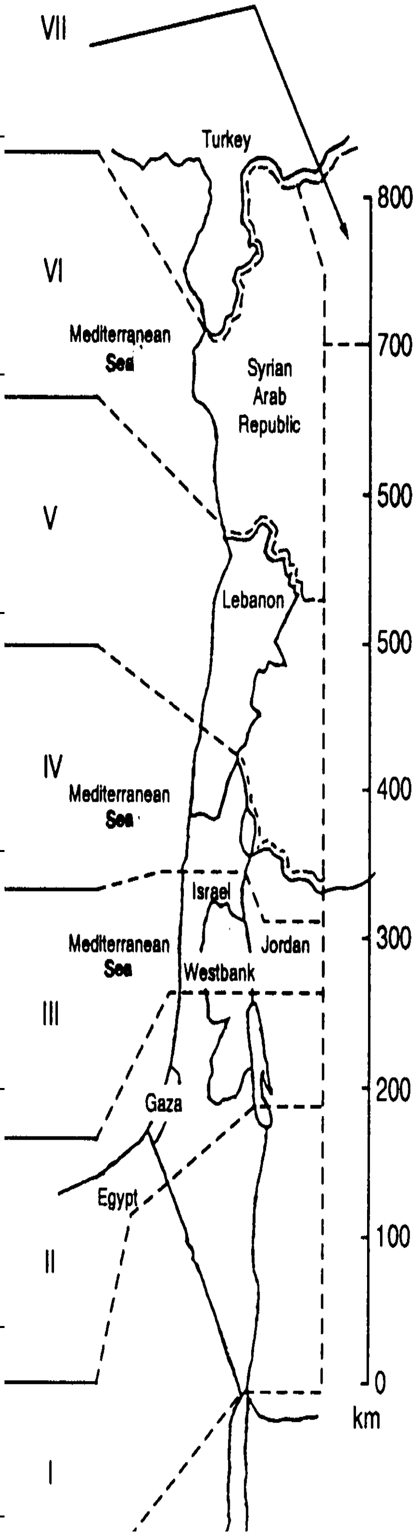

Figure 7. Eradication phases for the Middle East project (IAEA 1995).

The area was divided into zones according to national boundaries for quarantine purposes, and according to geographical-topographical features and host density and distribution for logistic and technical reasons, including the need to protect fly-free areas from those still infested.

Table 13 shows, for each country, the corresponding zones and for each zone the total host area divided into three categories (urban areas, commercial orchards and other areas). Intensity and frequency of sampling and control activities are variable in each of the three categories of host area as indicated in the technical plan.

In the Southern part of the region fruit crops are less diversified (i.e. mainly citrus are grown) with a higher degree of isolation and the terrain is less rugged. Under these conditions medfly populations tend to be less abundant. These characteristics allow for a less demanding operation and for higher chances of success in the initial stages of the program, thus eradication actions were planned to run from south to north. The area considered in this study extends from Gaza in the Palestinian Territories, southern Israel and Jordan, northward to the border between Syrian Arab Republic and Turkey (Figure 7).

For each zone, the eradication strategy includes the following phases: pre-eradication, eradication, post-eradication and fly-free area. Once pre-eradication has been completed in a working zone, eradication is enforced in that working zone and pre-eradication takes place in the adjacent working zone. All zones will pass through the sequence of four steps and will require 3 to 4 years from initiation of pre-eradication activities until the verification of fly-free status. Considering that the project is active and advancing in direction from south to north, at some stage, different project phases will be implemented in different zones in the same year. For example in year 3 zone I will be a fly-free zone, zone II will be in the post-eradication phase, zone III will be in the eradication phase and zone IV will be in the pre-eradication phase (Figure 7) (IAEA, 1997).

According to this general strategy, and if the sequence of phases in the eradication process is achieved on time in each zone, the region (Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic) would be declared fly-free by year 9.

3. ECONOMIC ANALYSIS

3.1. Cost assessment

Costs are assessed in four ways: 1) direct damage to fruit production due to medfly infestations, 2) indirect damage (environmental impact) from present medfly control, 3) costs of the present control programs and 4) costs of the alternative control options. Prevention of costs 1, 2 and 3 are considered as benefits for the proposed alternative medfly control options.

3.1.1. Direct damage

For Israel, which has a very efficient area-wide bait suppression program, the costs of direct damage to fruit production are very low. For all crops medfly causes an average yearly damage of 0.15%, which is equivalent to a loss of US $183 000, compared with revenues of US$337 million in 1994 (see Table 8).

In the Palestinian Territories, with less efficient operations, damage is higher and reaches economic levels particularly in non-citrus fruit crops. Damage to citrus, has been estimated at 0.4%, which is higher than in Israel but still well under a level which would justify further control efforts. However, average yearly damage in other fruits ranges from 2 to 6% depending on the environmental conditions. Using the lower of these damage level figures, in the Palestinian Territories the estimated losses are in the order of US $1.1 million per year, compared to annual revenues of US $78 million (see Table 8).

In Jordan, medfly causes severe economic damage. The calendar spraying with conventional insecticides used against this pest is not efficient enough to keep the pest under control. Despite conventional spraying, the estimated damage figure for all commercial fruit hosts is on average 29%, equivalent to US $56 million/year compared to an annual revenue of US $195 million (see Table 9).

In Lebanon, the calendar spraying against medfly is effective for most of the pome and stone fruit species. However, for the late varieties of citrus and some of the subtropical fruits, which are more susceptible, average damage is estimated to be 20%. The total loss of fruit crops in Lebanon due to direct medfly damage is estimated to be US $16.4 million per year despite the control efforts, (see Table 10).

Overall the yearly loss of fruit production in Syrian Arab Republic amounts to an estimated US $38.8 million when control measures are used. Without control the potential damage has been estimated in US $153 million per year which is around 51% of the total value of medfly fruit hosts in Syrian Arab Republic.

It has been estimated that if medfly was left without control, the average yearly damage (i.e. only commercial fruit loss) for Israel would be at least 29.6%, for Palestinian Territories 29.0%, for Jordan 37.7%, for Lebanon 51.3% and for Syrian Arab Republic 51.8%, equivalent to US $99.6 million, US $22.7 million, US $73.7 million, US $95.7 million and US $153 million, respectively. The total annual direct damage of commercial fruits for the four countries and the Palestinian Territories would be about US $445 million.

The difference and/or similarities between damage levels within the countries is related to environmental conditions (mainly temperature and relative humidity) and the crops and

varieties grown in each country. The dominant crop in Israel and the Palestinian Territories is citrus. In Israel 61% of the total area planted with medfly hosts is citrus. In the Palestinian Territories this figure is also over 60%. This probably accounts for the fact that damage levels are almost the same despite Israel having a much more diversified fruit industry. In the case of Jordan, the fruit industry is very diversified (and so susceptible) and furthermore the Jordan Valley, where at least 60% of the fruit crops are grown, offers ideal environmental conditions for medfly throughout the year (Enkerlin and Mumford, 1995). In Lebanon citrus is the dominant crop and around 21% of the total citrus area is planted with Valencia orange which is a late variety, highly susceptible to medfly attack (Enkerlin, 1997). This same is true for Syrian Arab Republic apart from the fact that there are almost 11 000 hectares of figs (the highest figure in the Middle East) highly susceptible to medfly infestations.

3.1.1.1. Estimated losses among backyard fruits

As part of the direct damage an estimate of the value of backyard fruits that would be lost from medfly infestations was done assuming the following: In the region there are, on average, 1000 households per square kilometre of urban and suburban area (IAEA, 1997). One out of three households has in its backyard an average of three fruit trees, the remaining households have no fruit trees. So approximately 1000 fruit trees are planted per square kilometre in backyards. The total urban and suburban area in the region (Israel, Palestinian Territories, Jordan, Lebanon and Syrian Arab Republic) has been estimated to be 5613.7 square kilometres. Multiplying the total amount of fruits trees per square kilometre by the total area results in 5.6 million fruit trees in backyards.

In the domestic market the average commercial value of the most common fruits in backyards (fig, guava, peach, orange and apple) is US $0.4/kg. We assumed that the value of the fruits in the backyards is a quarter of the average commercial value, or US $0.1/kg. By computing the average commercial production of a range of fruit trees (common in backyards in the Middle East) we have estimated an average yield of 68 kg per fruit tree. If we assume that in backyards, with no special care, fruit trees produce 25% of what they would produce under commercial conditions we have that each tree yields 17 kg. Furthermore we have assumed a 70% average medfly damage to fruit trees common in backyards considering that, normally, no control measures are applied by owners.

If we multiply the total trees in the region by the average yield lost per tree from medfly damage and by the average price of the backyard fruit (5 613,700 trees x 17 kg x 0.7 loss x US $0.1) we get an estimate of US $6.7 million as the annual value of the fruits being destroyed by the medfly in backyards.

3.1.2. Environmental impact (indirect damage)

For Israel, Jordan and Lebanon some information was available to assess the partial environmental impact of the use of insecticides for medfly control.

In the case of Israel, in the past 15 years (1980–1995), 1,032 tonnes of malathion ULVC 95 & 80% (technical material) have been sprayed on citrus for control of the medfly and another 500 tonnes have been sprayed on other fruit crops for the same purpose.

Adverse effects of malathion to the environment have already been reported in Israel. Among the negative effects are reduced pollination due to bee mortality (e.g. on avocado) and

outbreaks of secondary pests in subtropical crops (e.g. mango) due to high mortality of natural enemies. The best known case are outbreaks of Oriental scale and mealy bugs in mango orchards that are managed under an absolute biological control program, causing yield reductions of at least 80% (personal communication, Department of Crop Protection and Extension Service Ministry of Agriculture, Israel). Mortality of natural enemies due to malathion drift during aerial bait sprays against the medfly, has been found to be one of the main causes of outbreaks of these secondary pests (Ausher, 1995).

In Israel, integrated pest management (IPM) is being implemented on a country-wide scale. In 1994, 20% of the total deciduous cultivated area was under IPM practices. The country-wide aerial spraying of malathion, against the medfly, has been identified as one of the limiting factors for the IPM program expansion (Ausher, 1995).

If the area-wide bait suppression program were continued for the next 14 years (time frame of the project) around 1331 metric tonnes of malathion (technical material) would be sprayed into the environment for medfly control. Under this scheme, environmental problems would be exacerbated and, potentially, resistant medfly strains could develop (Vinula *et al*., 1982). This would increase production costs, affecting profits of the fruit industry that has shown, in the past 20 years, a downward trend due to lack of competitive advantages in the market (see Section 1.3.1.1).

Under the current control program in Israel, the cost of yield reduction by secondary pests because of malathion drift during aerial bait sprays is assessed for an estimated 25% of the pome and stone fruit producing area where only beneficial insects are used to control pests. It is also assessed for mango and persimmon where recurrent secondary pest outbreaks are known to occur due to mortality of natural enemies (Ruben Ausher, personal communication, Department of Crop Protection, Ministry of Agriculture, Israel). The total value of fruits at risk from secondary pest outbreaks has been estimated to be US $58.5 million per year. Malathion drift is assumed to occur in 1 out of 10 applications (10%) and it is assumed that when drift occurs 90% of the time secondary pests will cause damage resulting in 80% loss of yield in real circumstances. These figures were obtained by expert opinion from the Department of Crop Protection and from the Extension Service, Ministry of Agriculture, Israel). The expected average loss due to drift is 7.2% ($0.1 \times 0.9 \times 0.8$) of the crop value at risk from secondary pest outbreaks or US $4.2 million (US $58.5 million × 0.072) per year. Over 14 years this would amount to at least US $58.8 million if SIT-SUPP or SIT-ERAD where not implemented.

In Jordan, the Mediterranean fruit fly is controlled using calendar spraying. In 1995 around 132.8 metric tonnes of organophosphates (dimethoate and lorsban) were sprayed in fruit orchards to control this pest. Because of the lack of a medfly area-wide monitoring and bait spray program, adverse effects to the environment produced by medfly control are more serious than in Israel. Crop production has suffered because of outbreaks of secondary pests due to natural enemy deaths. Honey production is significantly reduced because of weakening of bee populations in beehives. Human health is at risk because of exposure to insecticide particles and vapours.

No scientific information is available in Jordan to quantify the effects of insecticide use on the population of natural enemies. However, farmers and agricultural extensionists have enough practical experience and empirical knowledge to distinguish and quantify some of the damage caused by secondary pest outbreaks on fruit crops due to natural enemy mortality because of

pesticide use. In other parts of the world, the impact of insecticides on non-target species has been measured. For example, Ehler *et al* (1984), attributed population increase of gall midge *(Rhopalomyia californica*) to the destruction of its parasite following 12 applications of malathion-bait to control the medfly in Northern California.

An example in Jordan is the area-wide control of the citrus spherical mealy bug using natural enemies. This key pest of citrus was effectively controlled by an introduced parasite. A well co-ordinated effort on the rational use of pesticides by the parties involved was one of the main factors contributing to the establishment of this natural enemy. Once the technology had been transferred to the farmers they were left alone to continue with this successful program. Unfortunately, after some time, some of the farmers, influenced by pesticide companies, went back to the traditional use of pesticides, affecting the natural enemy and, as a consequence, mealy bug outbreaks started to appear once more on a yearly basis (Marwan Abdel Whali, personal communication, Ministry of Agriculture, Jordan).

The most common and important secondary pests in Jordan are reported to be spherical mealy bug, several hard scales and, recently, the citrus leaf miner. Because of their biology and habits these insects are some of the most susceptible to biocontrol agents and normally are kept under control in environments where pesticides are used rationally. However, these groups of insects are typically found as secondary pests in environments where insecticides have been used in excess and could be used as indicators of ecological disruption. For example, on apple, San Jose scale, oystershell scale, woolly apple aphid, etc. have reached outbreak levels following destruction of natural enemies by pesticides (OTA, 1979) cited by Pimentel *et al* (1992).

According to experienced scientists and agricultural extensionists, in Jordan secondary pest outbreaks cause from 15 to 20% damage, mainly in citrus and stone fruits. This represents a loss of US $14.2 million per year for these fruit crops (Table 14).

In relation to effects of pesticides on honey production, at least 30 000 beehives exist in Jordan which produce every year up to 200 tonnes of honey, with a value of approximately US $0.4 million. However, this production is not enough to supply the present yearly demand of 645 tonnes. Around 485 tonnes of honey are imported each year mainly from Australia and the Palestinian Territories. To reduce this deficit the Ministry of Agriculture is encouraging honey production in Jordan.

Insecticides represent a serious limitation to the honey industry in Jordan. Because of the way bees metabolize insecticides they are especially susceptible to organophosphates that represent more than 60% of the insecticide used in Jordan. In winter beehives must normally be moved from the uplands down to the Jordan Valley where insecticides are used in excess and no effective procedure is used to protect the hives from insecticides during spraying.

Gary and Mussen (1984) evaluated the impact of malathion spray against the medfly in California and found significant mortality of adult bees associated with weekly applications, reducing colony populations to levels that would cause economic loss and threaten winter survival of colonies.

The Animal Production Department of the Ministry of Agriculture in Jordan has established that at least 25% of the beehives are not productive because of bee mortality due to insecticide

Table 14. Indirect costs of medfly control in Jordan 1996. (Enkerlin and Mumford, 1996)

Secondary pest outbreaks (crop value US $77.3 million)	**Loss (%)**	**Frequency**	**Crop loss (US $mn)**
Factor			
1 Natural enemy mortality		0.74	
1.1 Sec. pest outbreaks		0.37	
1.1.1 Extra spray	5	0.15	0.58
1.1.2 No spray	80	0.22	13.6
1.2 No secondary pests		0.37	
2 No natural enemy mortality		0.26	
Subtotal			**14.18**
Reduction in honey production	**Units**		**Loss (US $mn)**
No. of beehives (total)	30,000		
Honey production (tonnes)	200		
Production per beehive (kg)	6.7		
Price of honey (US $/kg)	2		
Value of honey per beehive (US $)	13.4		
Value of honey production (US $mn)	0.4		
Beehives affected by pesticides (%)	25		
No. Of beehives affected	7500		
No. Of beehives affected because of medfly control (50%)	3750		
Subtotal			**0.05**
Effect on human health	**Units**		**Loss (US $mn)**
Population in Jordan (mn)	4.5		
Rate of people poisoning	30:100,000		
No. of poisoning per year	1350		
Average cost per treatment per person (US $)	1207		
Cost of treatment in Jordan (US $mn)	1.63		
% of total pesticides used in Jordan for medfly control	33.8		
Cost of treatment against poisoning with insecticides used for medfly control (US $mn)			
Subtotal			**0.55**
Total			**14.8**

drift or direct contact during bee foraging. The health authorities have already found insecticide residues on honey for human consumption in Jordan.

Taking these figures into consideration, 7500 beehives are estimated to be affected each year by insecticides. If we attribute 50% of this damage to insecticides used against medfly, this results in 3750 beehives affected. On average in Jordan each beehive produces 6.7 kg of honey at US $2 per kilogram. So the value of honey per beehive per year is US $13.4, and US $50250 (US $13.4 × 3750 beehives) for the total hives affected by insecticide spray against the medfly or 12.6% of the total value of honey production in Jordan (Table 14).

Concerning effects of insecticide on human health, a World Health Organization and United Nations Environmental Programme report (WHO/UNEP, 1989, cited by Pimentel *et al*.1992) estimated that there are one million human pesticide poisonings each year in the world, with approximately 20 000 deaths. A higher proportion of pesticide poisonings and death occurs in developing countries where there are inadequate occupational and other safety standards (Pimentel *et al*, 1992).

It is well known that agricultural workers in the Middle East are more exposed to pesticides than others in the world (Davies and Freed, 1981, cited by Hamarsheh, 1989). In Jordan in 1984, the estimated rate of poisoning was 10 persons per 100 000 (Hamarsheh, 1989). However, at present (12 years later) experienced academic staff of the Jordan University for Applied Science consider this figure underestimated. In Jordan, in the past 15 years, considering the increase in agricultural area, in the amount of pesticide use and in man-hours dedicated to field and greenhouse spraying, academic staff suggest that the rate is at least three times more (30 persons per 100 000). With a population in Jordan of nearly 4.5 million this would result in 1350 cases of moderate to severe poisoning per year.

Considering the cost of atropine injections to be US $552 (138 injections/person × US $4/injection), hospitalization US $415 (8.3 days in hospital x US $50/day) and US $240 (US $2/hr × 8 hrs/day × 15 days) for lost work due to poisoning, the cost of an average treatment has been estimated at US $1207 per person (expert opinion from University of Applied Science, Jordan). With 1350 cases per year this would result in US $1.63 million spent in Jordan for treatment of moderate to severe intoxications for all pesticides (Enkerlin and Mumford, 1996).

Each year an average of 94 tonnes of insecticide (i.e. technical material) are used to control medfly in Jordan. This represents 33.8% of the total pesticide use in the country. This means that around US $554,200 (US $1.63 million x 0.34) is spent each year for treatment of persons poisoned when spraying against medfly assuming equal likelihood of medfly spray causing poisoning compared to other sprays.

If the conventional control methods continue to be used in Jordan for medfly control, 1859 tonnes of organophosphates will be sprayed in the environment in the next 14 years, enhancing the adverse effects already mentioned. At least 5.4 times less insecticide would be sprayed into the environment if the SIT-SUPP (344.4 tonnes) control option was used and almost 15 times less if SIT-ERAD (125 tonnes) was used.

In Lebanon, the broad spectrum insecticides used and indiscriminate spraying methods (no pest monitoring devices are used) seriously affect the populations of beneficial insects resulting in outbreaks of secondary pests like whiteflies and in the appearance of new pest organisms such as spider mites and, recently, citrus leafminer (Katsoyannos, 1995). To measure the environmental impact of medfly control in Lebanon is a difficult task because no data are available to quantify damage by secondary pest outbreaks, reduction in yield because of low output of beehives, reduction in honey production and effects on human health (Pimentel *et al*., 1992). However, some recent work done by the ARI has produced some clear indicators of the ecological disruption caused by the inefficient use of pesticides. For example, partial results of an experiment to survey and estimate the level of parasitism of leafminer in non-sprayed citrus plots, show that at least two different species of parasites (Eulophidae) are present. In these plots levels of natural parasitism have reached up to 60% with an average of at least 20% (Salma Kilani ARI, personal communication). This is a clear indication that

natural enemies are still present in significant numbers and that benefits could be obtained from them if insecticides were used rationally. At present one of the research priorities at ARI is to conduct more laboratory and field experiments on natural enemies and their potential use against pests of fruit crops in Lebanon. Also recently some of the strongest pesticide companies (e.g. UNIFERT) in Lebanon are promoting the use of more selective pesticides such as microbial insecticides against whiteflies and lepidopteran pests and spot applications using baits against the medfly that could be commercially available during the present year.

Eliminating or controlling the medfly using the SIT would allow, in some crops such as citrus, the use of area-wide biological control programs against the other economic pest known to be susceptible to natural enemies, such as mealy bugs, scales, whiteflies and leafminers.

Another indicator of the inadequate use of pesticides in Lebanon can be found in the bee industry. Lebanon has around 60,000 beehives that produce ca. 600 tonnes of honey per year. Beehives are used for honey production and pollination purposes. Every year around 25% of the bee population is killed by insecticides causing a loss of 15% in honey yield which amounts to US $450,000 per year (600 tonnes × 0.15 × US $500/tonne) (Jaseph Féghali, personal communication ARI). Knowing about the high susceptibility of bees to organophosphate insecticides, an important amount of this loss can be attributed to the dimethoate and malathion used to control medfly and other economic pests (Gary and Mussen, 1984).

Another important consideration is that, in the past, the traditional import countries in the Gulf did not request from Lebanon minimum levels of pesticide residues in fruits. This situation has changed in recent years and regulations and controls are being established and implemented by these countries. This is an important extra pressure for farmers, chemical companies, exporters and the official sector which must put more effort into regulating the use of pesticides to meet the required standards, promoting adequate spraying practices and creating the necessary infrastructure for pesticide quality control and analysis of residues of import and export fruit products.

Based on the available data, it has been estimated that the indirect costs of the use of pesticides in Israel (US $4.2 million), Jordan (US $14.8 million) and Lebanon (US $19.6 million) total approximately US $38.6 million each year. This figure includes crop loss due to secondary pest outbreaks (for Israel, Jordan and Lebanon), honey losses due to beehive weakening (for Jordan and Lebanon) and treatment of persons with acute poisoning by accidental intoxication (for Jordan).

However, this assessment is incomplete because data are scarce. A complete accounting of the indirect costs should include death by insecticide poisoning, costs of chronic poisoning such as cancer treatment, costs of mild intoxications, beehives lost from pesticides, pollination losses, water and soil pollution, domestic animal poisonings, losses of fish and wild life, etc. If the full environmental and social costs could be measured as a whole, the total yearly indirect costs would be much greater than the estimated US $38.6 million.

3.1.3. Costs of present control programs

For medfly control in Israel US $5.2 million is spent each year. This includes aerial bait sprays (60.8%), post harvest treatments (28.8%), trapping (5.8%) and administration (4.6%). For the Palestinian Territories US $1.2 million is spent each year with 88% of the cost corresponding

to bait sprays, 4.2% to trapping and 7.8% to administration. In Jordan US $2.1 million is spent per year for conventional spraying of organophosphates to control the medfly, US $3.5 million in Lebanon and US $1.6 million in Syrian Arab Republic. At present the regional cost for medfly control is US $13.6 million per year.

For the four countries and the Palestinian Territories, the cost per ha per spray is: for Israel US $6.5, for the Palestinian Territories US $10, for Jordan US $14, for Lebanon US $50 and for Syrian Arab Republic US $22.

In Israel, private companies are hired to provide aerial bait spray services. In the Palestinian Territories, aerial bait sprays are not feasible because farmers have their houses within the fruit orchards. The government coordinates 12 brigades of 6 to 8 people each to apply weekly ground sprays over the total citrus area. In Jordan, aerial sprays are also not feasible and conventional ground spraying is done individually by each orchard owner using total coverage of the fruit trees. In Lebanon conventional spraying is also done using ground application. Some fruit growers hire insecticide application services and others apply insecticides by themselves. In Syrian Arab Republic, insecticide applications against medfly are only done for stone fruits and figs. In most cases farmers spray by themselves using ground cover sprays.

In the case of the Palestinian Territories the large amount of expensive manpower required makes ground spraying at least 1.5 times more expensive than aerial bait sprays. For Jordan the difference is even greater (2.1 times more) as a result of no coordinated effort for spraying and also no bait used to allow for partial coverage. Furthermore, the lack of a monitoring system in the West Bank and in Jordan makes medfly control in these areas much less efficient. The cost for Lebanon is extremely high compared with the costs for Jordan, Palestinian Territories and Israel. Monopolies controlling the pesticide business in Lebanon and lack of governmental intervention for price control are thought to be the responsible factors for the extremely high price (Enkerlin, 1997). Compared to the Palestinian Territories and Israel, which use supervised bait spray control, the cost is around 6 times higher and 3.5 times higher if compared with Jordan which also applies the conventional control methods. In Lebanon the average citrus grower is forced to accept loosing 15 to 20% of the yield before spraying 1 or 2 times more to save the crop.

In Israel, post harvest treatments represent almost 29% of the total medfly control costs. Around US $1.5 million is spent, each year to treat oranges, grapefruits and persimmons by cold temperature in Israel before shipping them to Japan and the USA. Also peppers from the Arava Valley are imported by the USA using a "system approach" (i.e. strategic integration of a number of techniques to minimize the risk of pest introductions to free countries or regions) to guarantee fly-free status. Melons and tomatoes are imported under the concept of "non host status".

Japan is also interested in importing melons and peppers from Israel, however they will not accept the "non host status" concept and no post harvest treatment is available for these commodities.

South Korea is a very interesting potential market for Israel. However, at present the export market is closed because they require the development of post harvest treatments according to their specific protocols. American or Japanese protocols are not accepted.

As this information shows, quarantine regulations are a very important obstacle for the development of the fruit industry in Israel and the entire Middle East region, including the Palestinian Territories, Jordan, Lebanon and Syrian Arab Republic. As has been shown, Israel's traditional European export market is being lost to stronger competitors. An alternative would be the diversification of the export market. However, this is not being achieved, sometimes due to the lack of effective post harvest treatments and other times by the high costs of the treatments.

It is very difficult to quantify the damage in money due to opportunities lost in alternative markets because of quarantine restrictions against the medfly or because of lack of post harvest treatments. However, we certainly know that eradication of the medfly would immediately eliminate all these restrictions and new and better opportunities for the fruit industry of the region would emerge (conditioned to the market not creating other barriers) as will be shown further on by the economic indices estimated for this control option.

3.1.4. Costs of the alternative control options

Using a spreadsheet (Quattro Pro, version 6.01 for Windows), a number of matrices were prepared to calculate operational and capital costs for each of the alternative control options. Costs were calculated by zone, by country, for the region and also by year. Included are all the technical activities (trapping, fruit sampling, bait sprays, bait stations, sterile flies and quarantine), capital investment in equipment and infrastructure as well as public advertisement, training and methods development. In the case of the SIT-SUPP and SIT-ERAD options, a cost for emergency reaction to outbreaks in fly-free areas or a population explosion in areas under suppression was also considered.

The strategy and technical plan of each control option indicates the timing, frequency and intensity of each technical activity. These were used as the basic guidelines to calculate the costs. A unit cost was assigned to each activity. These costs are based on estimates done during the assignments in Israel, Jordan, Lebanon and Syrian Arab Republic as well as on costs presented in various documents prepared by expert groups of the IAEA and by the Mexican National Fruit Fly Campaign (CNCMF), (IAEA, 1997 and SARH, 1991).

The final cost figures for each control option are presented in the result and discussion chapters.

3.2. Benefit assessment

The benefits of the three control options analysed for medfly control are given by: 1) increase in production volumes due to medfly control, 2) savings in environmental costs, 3) savings in costs of the more expensive conventional control methods and 4) market gain due to meeting higher quality standards (pest and pesticide free produce). The second and third benefits are related to the costs of the conventional control methods and would be transformed into benefits if any of the alternative control options were implemented. For this reason they have been discussed in the previous section which deals with costs.

Considering that the BAIT-SUPP option has no real market advantages over the present control methods (actually it is the control method being used at present in Israel and parts of the Palestinian Territories), the market gain benefit has been excluded for this option. In the case of SIT-SUPP the lower control costs and reduced pesticide residues on fruit will produce

advantages to compete better in domestic markets and export markets not requiring fly-free status but that discriminate for "low pesticide level" products. For SIT-ERAD the elimination of pesticide residues from medfly control and the elimination of the pest itself will produce comparative advantages not only to compete better in the domestic markets and export markets not requiring fly-free status but also in the export markets that discriminate for "pesticide-free" and "fly-free" products.

For the options that can benefit from a market gain, a sensitivity analysis was made using five levels of market gain (0%, 10%, 25%, 50% and 100%). Considering that the planted area and production volumes would need to increase in order to supply the extra market gained, in the spreadsheet matrix the market increase comes in a gradual form gaining 17% of the potential level (i.e. 100% increase in market) per year. A 17% in average market gain per year was assumed considering the present high expansion rate in area and production volumes for some of the high value fruit crops in Israel and Jordan (Emanuel Dlayahu, personal communication, Rural Planning Department Ministry of Agriculture). According to the project strategy discussed previously the SIT-SUPP option is fully implemented by year 2 so the gradual market gain starts in that year, reaching full gain by year 7 (17% market gain × 6 years = 100%). On the other hand, for the SIT-ERAD option and for Israel, the Palestinian Territories and Jordan full implementation is only reached in years 4 and 5, so the market gain begins during those years and reaches full gain by year 9. Whereas for Lebanon and Syrian Arab Republic full implementation is reached in years 7 and 10 and market gain reaches full potential gain by years 9 and 14 respectively.

3.2.1. Production and market model

To work out the total benefits for each country and control option, all the variables related to benefits were concentrated on a production and market spreadsheet matrix. The matrix includes, for each country and fruit commodity, high and low input fruit production (IAEA, 1997).

The production matrix includes data on planted area and yields per fruit commodity to estimate the total production, in metric tonnes, for each fruit and for the whole fruit industry. Prices per kg of fruit in the various markets (domestic, export not requiring fly free status and export requiring fly-free status) are also included to estimate fruit production revenues, in millions of US dollars, per fruit commodity and the total. Having estimated the value of the fruit production, a medfly damage function, with control and without control, is used for each fruit commodity to estimate the potential loss in millions of tonnes and millions of US dollars due to direct damage.

In this same matrix, the number of insecticide sprays per fruit crop, as well as the cost per spray per hectare, is included to estimate the cost of the conventional control methods, reduction of which is considered part of the benefit for the alternative control options analysed.

The market matrix includes, for each control option, the present quantity, in millions of tonnes, of fruit being sold in each market (domestic, export not requiring fly-free status and export requiring fly-free status) and the potential amount (market gain) that could be sold in each different market category according to the control option being analysed. Differential prices for the fruit commodities for each of the market categories are considered. A limit on export sales is set based on recent exports from each country as well as on present

infrastructure and future possibilities for increased exports (Enkerlin and Mumford, 1997). For example, if the matrix is being run for the BAIT-SUPP option, only the present amounts being sold to domestic or export markets not requiring fly-free status would be considered to estimate the revenues. Whereas if the matrix was to be run for the SIT-ERAD option the present amounts of fruit being sold as well as the potential amounts to be sold to the three market categories would be considered to estimate the revenues. The standard potential amount or market gain, used to run the matrix for calculation of the economic indices for the SIT-SUPP and SIT-ERAD options was 25%.

It is important to make clear that in the case of Lebanon and Syrian Arab Republic for the SIT-ERAD option, at present, exporting significant amounts of fruit commodities to high value markets (e.g. Japan, USA, Korea, etc) that discriminate for fly-free products is unlikely.

Although, after eradication, fruits would qualify for these markets, in a 14 year regional project where fly-free status, in the case of Lebanon and Syrian Arab Republic, is not achieved until year 7 and 10 respectively, in the short term the real possibilities of exporting fruit commodities to these high value markets are slim. Several factors are involved, probably the most critical ones being the lack of appropriate transport and storage facilities and, above all, the low quality of the fruit.

Not even fruit exports to the European Union (EU) market that will not discriminate for medfly-free products and which has in the past imported fruit commodities (e.g. Eastern Germany) from Lebanon would be an easy task. After suppression or eradication has been achieved, in order to consider trading with the EU, tariffs barriers should be abolished (there is tax free trade with the Arab countries), transport costs should be minimized and fruit quality should be increased. At present the most likely exports would be to Germany, countries in Eastern Europe and France because of the links that still exist from the colonial days (Bissat, 1991). Figure 8 shows the distribution, in percentage, of Lebanese fruit exports to Persian Gulf and Arab countries in 1995.

At present the Persian Gulf and Arab markets remain Lebanon's and Syrian Arab Republic's best alternative, especially since trade is tax free, transport is not a limiting factor due to distance (all fruit products are taken by truck) and prices are comparable to those of the EU (Bissat, 1991).

Also included in the benefit matrix is an estimation of the indirect damage of medfly control (secondary pest outbreaks, reduced bee pollination, reduced honey production and human intoxication). The procedures used to quantify the indirect damage have been discussed in the environmental impact section. In the case of Lebanon, due to the scarce availability of data related to this issue only a very rough and conservative estimate of 10% damage by secondary pest outbreaks was included. No estimate of damage by reduced bee pollination, reduced honey production and human intoxication was considered in the matrix. For Syrian Arab Republic no information on medfly indirect damage was available.

For each country and control option, the production and market matrix presents subtotals, in millions of US dollars, for each of the benefit variables discussed and a final total figure.

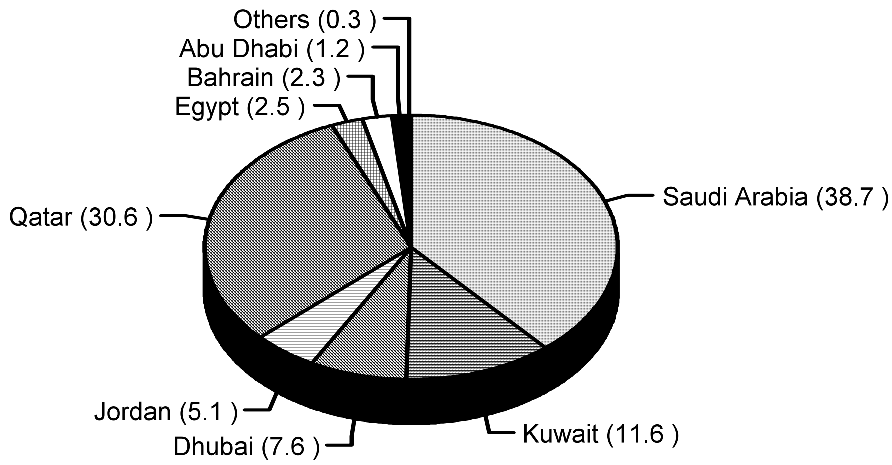

Figure 8. Lebanon percentage fresh fruit exports to Arab countries 1995 (Enkerlin, 1997).

3.3. Assessment of economic indices

To assess the economic returns of each control option a 14-year horizon was selected. Technically, 10 years is the minimum amount of time required to achieve fly-free status in the whole Middle East region. In theory a longer period of time (e.g. 20 years) would allow for higher net benefits and B/C ratios. However, considering political and social stability in the region, the outcome (economic indices) of an economic analysis using a time frame of 20 years would have a higher level of uncertainty. Nevertheless the model is flexible enough to compute the economic indices for any time horizon for comparison among control options.

For estimation of the economic indices a constant 10% discount rate is assumed for the whole region. These discount rates were based on interest and inflation rates in the region during the 1990–1997 period.

Costs and benefits, at net present value (NPV), were computed using the spreadsheet matrixes as described. The estimates were incorporated in an adapted version of the economic model used to evaluate the Maghrebmed program (Mumford *et al.*, 1995). The model provides estimates of the following economic indicators: net benefits, B/C ratio, internal rate of return to investment (IRR), return on equity (N/K), and payback period (FAO, 1984, Mishan, 1988 and Reyes *et al.*, 1991). Return on equity is assessed as the ratio of the present value of positive terms over negative terms in the cumulative flow of costs and benefits. The pay back period is established to indicate how quickly benefits are generated through the project. These economic indices were estimated for each control option at regional level and on a country by country basis.

Environmental benefits for the control options are indicated by comparing the cost of the pesticide based medfly control before and after the implementation of the project. A standard time of 8 years is used for comparison in every country and the Palestinian Territories. By year 7 most of the region is in a post eradication or fly-free status so insecticide use is compared over 8 years which is the time remaining before project completion.

4. RESULTS AND DISCUSSION: ISRAEL, JORDAN, LEBANON, PALESTINIAN TERRITORIES AND SYRIAN ARAB REPUBLIC

4.1. Costs

It has been estimated that in Middle East region (Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic) for medfly control, ca. US $190 million would be spent in a 14-year time frame by farmers using current control practices. In addition, another US $1662 million (US $118.7 million/year) would be lost, despite control, due to direct damage by pest (i.e. commercial and backyard fruit loss) and at least US $540 million due to environmental impact costs. This amounts to a total loss of US $2.4 billion for the whole region in 14 years.

4.1.1. BAIT-SUPP

The total cost for Israel, the Palestinian Territories, Jordan, Lebanon and Syrian Arab Republic for the 14-year project using the BAIT-SUPP option is US $587 million (includes program costs and environmental costs). Once BAIT-SUPP has been established in the whole region (from year 3) the cost per year is US $31.9 million (includes only program costs) that has been considered, for calculations of the economic indices, as a constant cost in the remaining 11 years of the program (Figure 9). However, it is possible to have an increasing trend mainly due to indirect damage (i.e. recurrent secondary pest outbreaks, accumulation of toxic residues and potential resistance) caused by medfly control when using this control option. For intensive fruit production, in the medium to long term, and considering the increasing worldwide awareness and concern for environmental issues, and the present shift to biocontrol techniques, specially for fruit production in the developing and developed world,

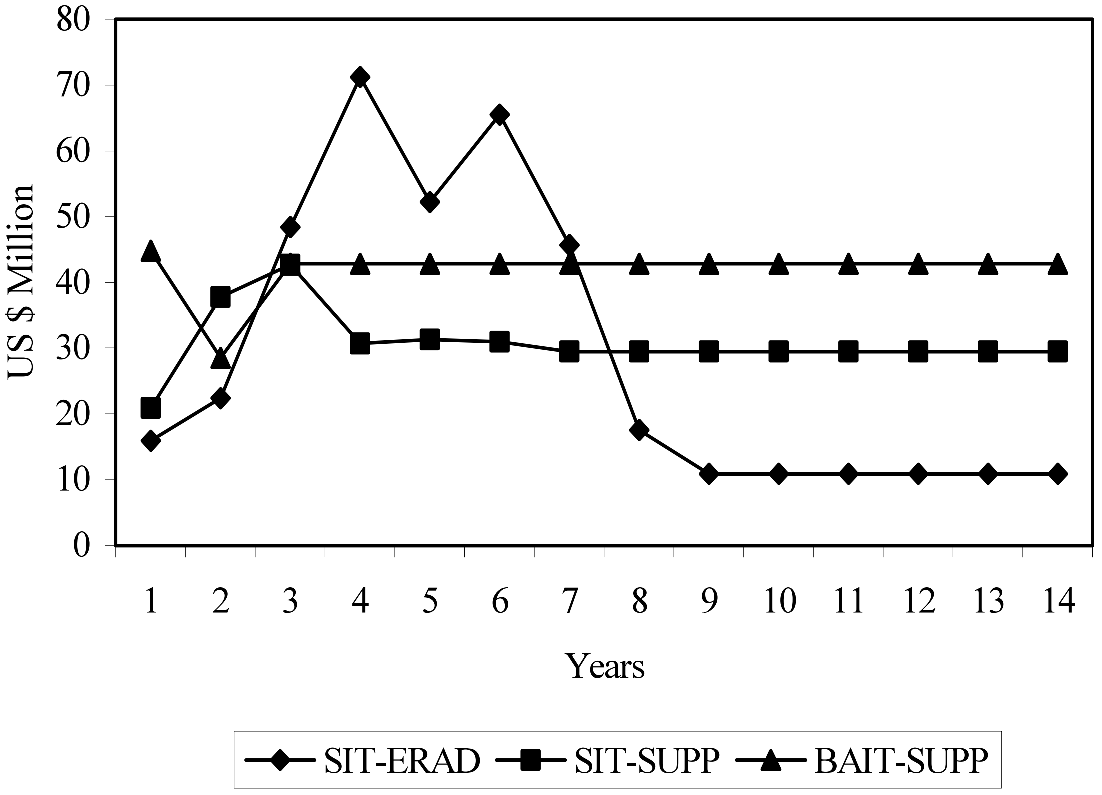

Figure 9. Annual costs for Mediterranean fruit fly control in the region (Israel, Jordan, Lebanon, the Palestinian Territories and Syrian Arab Republic).

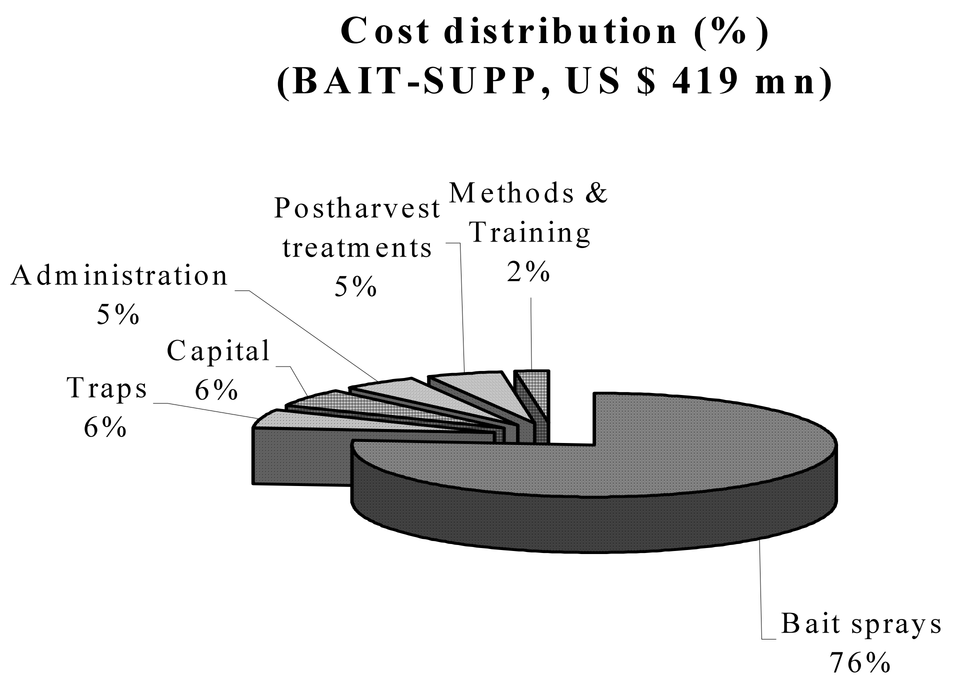

Figure 10. Operational percentage cost distribution for the BAIT-SUPP control option (US $419 million).

this control option might not be sustainable. Maintenance cost for capital replacement of spray equipment, higher costs for bait and malathion registration and use.

As explained previously, this control option relies on aerial and ground bait sprays, which represent 76.0% of the total costs. Postharvest treatments account for 5.0% and trap servicing for 6.0%. The rest correspond to non-technical costs (capital, administration, etc.), (Figure 10).

4.1.2. SIT-SUPP

For the SIT-SUPP option the total costs, for the 14-year project, are US $450 million. This include: operational costs, capital costs and costs in zones still under current control practices. This amount is US $137 million less than the BAIT-SUPP option and US $47.6 million more than the SIT-ERAD option. This option has a high ongoing cost due to the permanent release of sterile flies and use of bait sprays to suppress populations prior to the sterile fly release. By years 6 and 7, during the post-suppression period, the costs are US $31 million per year (includes only program costs) and stay constant through to year 14 (Figure 9). This control option relies mainly on sterile male releases that represent 55% of the total costs. 11.5% goes for bait sprays, 5.3% for post-harvest treatments and 4.3% for trapping and fruit sampling. In this case, capital costs have an important share (7.3% or US $29.2 million) due to the infrastructure needed for packing and storing the sterile flies (Figure 11).

4.1.3. SIT-ERAD

The total cost for the SIT-ERAD option, in 14 years, is US $403 million. This include: operational costs, capital costs and costs in zones still under current control practices.

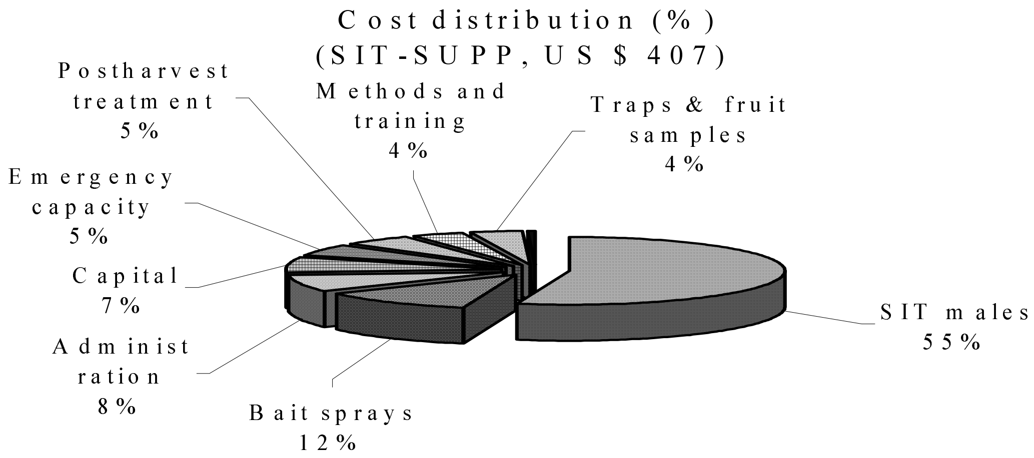

Figure 11. Operational percentage cost distribution (%) for the SIT-SUPP control option (US $407 million).

Although this alternative is the most expensive during the first 7 years due to the capital investment and intensive eradication actions, after 14 years, the overall cost is less compared to the other two alternatives. Being the main reason the substantially lower costs during the fly free period. During this period costs fall to US $11 million per year compared to US $31 million for the SIT-SUPP option and to US $32 million for the BAIT-SUPP option. 79.8% (US $321 million) of the costs concentrate during the first seven years when intensive eradication actions take place. From year 7 on, costs start to fall until they reach the lowest amount (US $11 million/year) in year 9 (Figure 9).

In relation to cost distribution, 42.0% correspond to sterile male (purchase and release) during the eradication phase, 15.0% to trapping and fruit sampling during all the project phases including the fly-free phase, 7.4% to bait spray and bait stations mainly during the pre-eradication phase and quarantine plus emergency capacity at 16.9% during post-eradication and fly-free phases. The rest (19.5%) corresponds to non-technical costs (Figure 12).

It is important to note that for this control option eradication activities must be performed in all areas where medfly hosts are present (i.e. orchards, urban and other areas). This more extensive strategy requires more money for operations during the initial phases of the program compared to the other control options.

4.2. Benefits

The differential value of the production saved from medfly is very small among the control options analysed. In terms of medfly control, the difference between the least effective option (BAIT-SUPP) and the most effective one (SIT-ERAD) is on average no more than 1%, due to the relatively high levels of control achieved by all options.

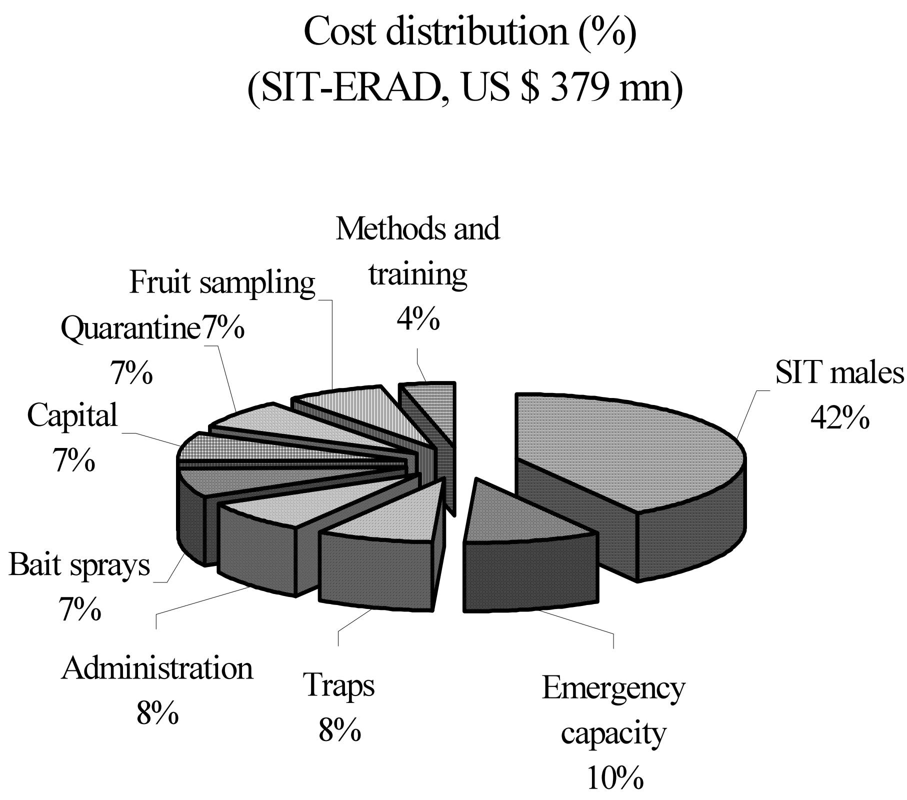

Figure 12. Operational percentage cost distribution for the SIT-ERAD control option (US $379 million).

Taking this into consideration, the benefits that will make a difference for the control options will be produced by the potential market gain and savings in environmental costs (secondary pest outbreaks, human health, reduced bee pollination and honey production, etc) of each control option.

4.2.1. Net benefits

4.2.1.1. BAIT-SUPP

As explained before, the BAIT-SUPP option is at present being successfully applied area-wide in Israel and the Palestinian Territories. Figure 13 shows for this option on a regional basis an accumulated net benefit (at present value) of $2892 million in 14 years (Table 15). These benefits correspond only to the value of the production saved due to medfly control.

From year three net benefits are constant. This is a result of constant costs and gross benefits due to lack of additional advantages to compete in the market. For this option, in the medium to long term, there is a risk of a downward trend in net benefits. As mentioned above, costs might increase mainly because of indirect effects of medfly control (e.g. secondary pest outbreaks, reduced bee pollination and reduced honey production, etc.) and also gross benefits might decrease due to export market loss or reduced production due to lack of interest from the growers for a low profit business. At present this is the trend for the Israel and the Palestinian Territories fruit industries (see Sections 1.3.1.1 and 1.3.1.2).

Table 15. Economic indices of alternative Mediterranean fruit fly control methods for a 14-year project in Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic using a 25% market gain

Control Option	Site	Gross benefits (NPV) (US $mn)	Net benefits(NPV) (US $mn)	B/C Ratio	Pay-back Period
BAIT-SUPP	Region	3197.0	2891.7	10.5	1
	Israel	733.7	--	7.3	--
	Palestine	166.9	--	8.6	--
	Jordan	542.9	--	7.1	--
	Lebanon	690.1	--	7.5	--
	Syrian Arab Republic	1063.4	--	11.5	--
SIT-SUPP	Region	3937.3	3673.1	15.8	1
	Israel	896.5	--	13.6	--
	Palestine	272.7	--	9.2	--
	Jordan	846.0	--	22.5	--
	Lebanon	836.4	--	27.3	--
	Syrian Arab Republic	1085.8	--	18.2	--
SIT-ERAD	Region	4149.7	3859.8	16.8	1
	Israel	968.3	--	20.8	--
	Palestine	266.7	--	8.5	--
	Jordan	844.3	--	18.2	--
	Lebanon	863.8	--	34.9	--
	Syrian Arab Republic	1206.7	--	12.2	--

4.2.1.2. SIT-SUPP

According to the project strategy, medfly populations are successfully suppressed in the entire region using the SIT-SUPP option by year 4. This means that by year 4 the fruit industry and society will be in a position to obtain all the potential benefits (i.e. market gain, savings in control costs and savings in environmental costs). In the case of the market, its gradual gain will start in year two reaching its full gain by year eight.

For this option from year 1 net benefits show an increasing trend. As the project goes on costs decrease to a constant level and gross benefits increase as the market opens to new fruit production. By year 8 net benefits reach a maximum and keep this level through year 14 (Figure 13). For a market gain of 25%, the accumulated net benefits (at present value) for this

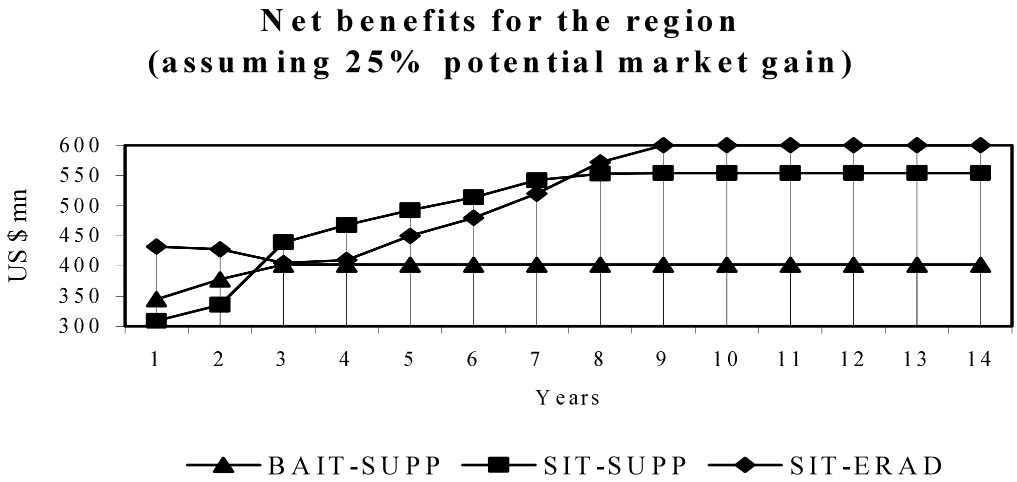

Figure 13. Net benefits for the region (Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic) assuming a 25% potential market gain.

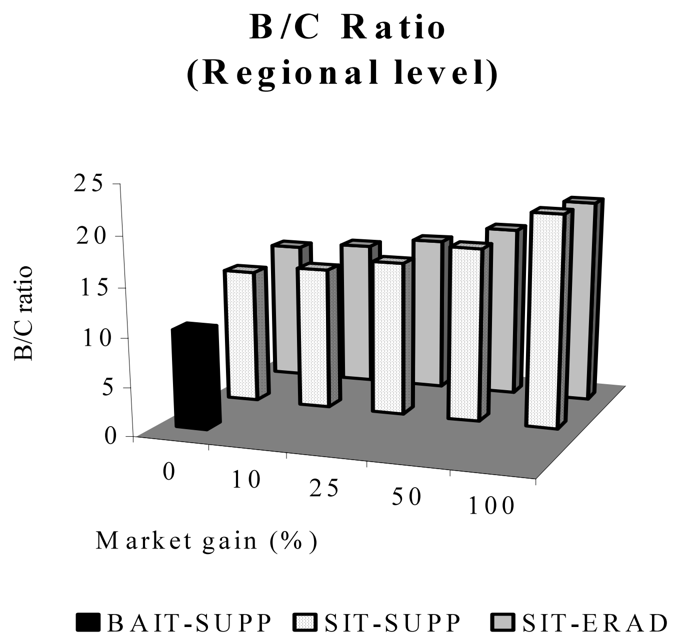

Figure 14. Benefit to cost ratio for the region (Israel, Jordan, Lebanon, Palestinian Territories and Syrian Arab Republic) for a range of market gains. Note that there is never a market gain for the BAIT-SUPP option, potential gains only apply to SIT options.

option are US $3673 million over 14 years which is 21% higher than the BAIT-SUPP option but 4.8% lower than the SIT-ERAD option (Table 15).

4.2.1.3. SIT-ERAD

For the SIT-ERAD option medfly populations are eradicated from the region (Israel, Palestinian Territories, Jordan, Lebanon and Syrian Arab Republic) by years 8 and 9 depending on the working zones. Except for the share of market requiring fly-free status, the

rest of the potential benefits are obtained for Israel, Palestinian Territories and Jordan from years 2 and 3, during the post-eradication phase, for Lebanon from years 5 and 6 and for Syrian Arab Republic from years 8 and 9.

The gradual gain of market requiring fly-free status will start for Israel, Palestinian Territories and Jordan in year 3 completing its full gain by year 8. For Lebanon the market gain will start in years 4 and 5 completing its full gain by years 9 and 10 and for Syrian Arab Republic in years 6 and 7 completing full gain by years 11 and 12.

For this control option, 77% of the costs concentrate in the first seven years (Figures 9 and 13). From year 9 on, during the post eradication and fly-free periods, costs show a substantial decreasing trend (to US $11 million/year) and gross benefits a substantial increasing trend due to higher export volumes and values going to markets requiring fly-free status. As a result net benefits reach their highest amount by year 9. From year 8, SIT-ERAD becomes the dominant strategy in terms of annual net benefits. The accumulated net benefits in the 14 year period are US $3860 million which is 4.8 and 25% more than those obtained by the SIT-SUPP and BAIT-SUPP options, respectively (Table 15).

4.2.2. B/C ratio

4.2.2.1. BAIT-SUPP

The B/C ratio for the BAIT-SUPP control option at the regional level (Israel, Jordan, Lebanon Palestinian Territories and Syrian Arab Republic) is 10.5 (Table 15). For each dollar invested a net return of 10.5 is obtained in the first and subsequent years. This economic return is high and reflects the efficiency of this control option. This option has the lowest economic returns as a result of higher overall costs and lower benefits since no extra benefits (i.e. market gain, savings from secondary pest outbreaks, damage to bee colonies, etc) are obtained (Figure 14).

The lack of additional market advantages for fruits produced using BAIT-SUPP keeps this option from gaining the extra benefits, resulting in a lower economic return compared to the other two options.

The difference in economic returns in favour of SIT-SUPP and SIT-ERAD options becomes greater as the market gain increases (Figure 14). This same trend can be observed on a country basis (Figures 15, 16, 17, 18 and 19).

4.2.2.2 SIT-SUPP

For the Middle East region SIT-SUPP is technically and economically a better option than BAIT-SUPP. Net benefits and benefit to cost ratio of the SIT-SUPP option are substantially higher than those from the BAIT-SUPP option (Figures 13 and 14). SIT-SUPP is a less expensive option (by US $136 million) and gross benefits are 18.8% higher due to the market gain and environmental savings. Benefits come early (ca. second year) due to the effectiveness of the technology and lack of quarantine restrictions to access new export markets not requiring fly-free status. Fruit is sold to a large, well established domestic market with unsatisfied demand and to a traditional export market not requiring fly-free status (i.e. Western Europe and the Gulf) but requiring high fruit quality, competitive prices and low pesticide residues. These requirements can be met by using the SIT-SUPP option with no need for eradication.

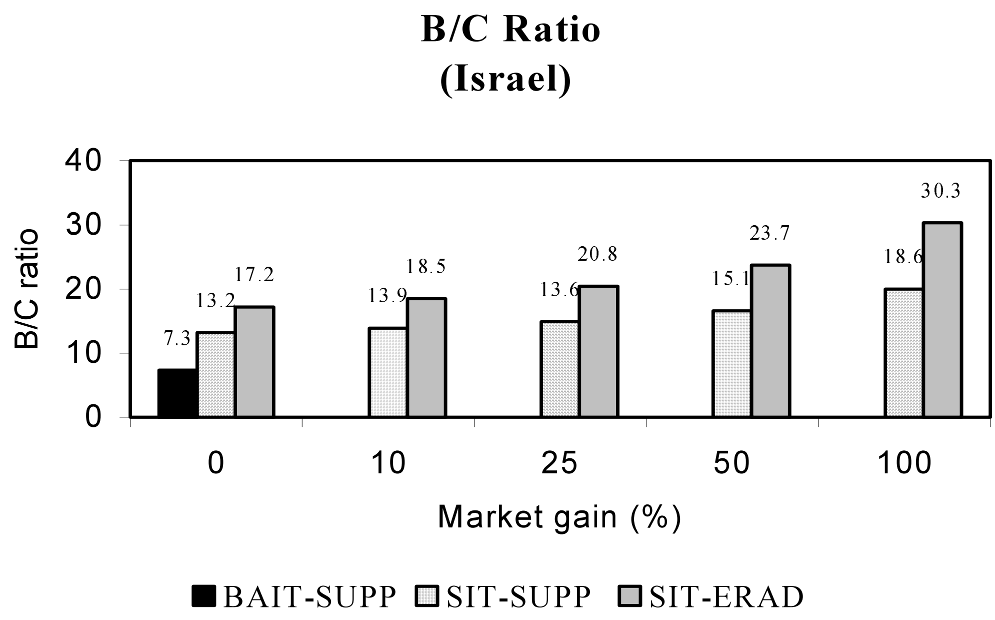

Figure 15. Benefit to cost ratio for Israel for a range of market gains.

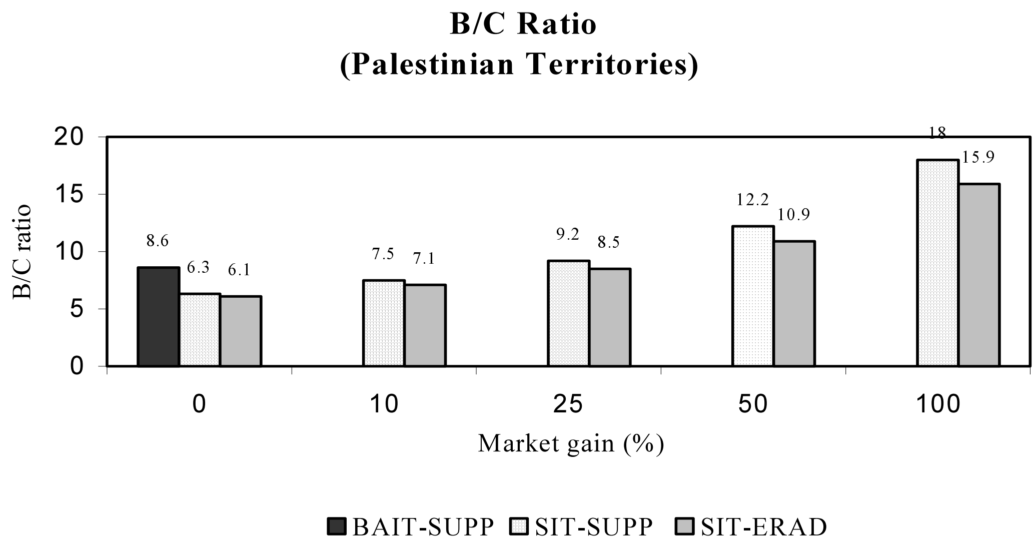

Figure 16. Benefit to cost ratio for the Palestinian Territories for a range of market gains.

However, comparing SIT-SUPP with SIT-ERAD, at regional level, the latter option gives slightly better economic returns even when control activities for the SIT-SUPP option are performed only on orchards and partially on urban areas and no intensive trapping or quarantine needs to be enforced to protect fly-free areas. This mainly results from having ongoing costs 2.8 times higher than the SIT-ERAD due the permanent use of bait sprays and sterile flies to keep medfly populations under control.

However, on a country basis for a 25% market gain, the SIT-SUPP option produces a higher benefit to cost ratio for Palestine (9.2), Jordan (22.5) and Syrian Arab Republic (18.2) than the SIT-ERAD option. In these three countries SIT-ERAD is more expensive then SIT-SUPP due to a much larger area classified under non-crop area or other area. Under a SIT-ERAD program these non-productive areas have to be intensively treated to achieve eradication. Furthermore, these three countries have a strong and unsatisfied domestic market and a well-established export market within the region. Benefits obtained from a market not requiring fly-free status come early and are of a much greater volume then those potentially obtained from fly-free markets that will come latter in the program once eradication has been achieved.

For Israel and Lebanon the benefit to cost ratio are 13.6 and 27.3, respectively. For these two countries the dominant option is SIT-ERAD as will be discussed further on (Figures 15, 16, 17, 18 and 19) (Table 15). Although Israel has the most technical and one of the largest fruit industries, its economic return for the SIT-SUPP option is one of the lowest in the region. Israel has a relatively large production area (the largest after Syrian Arab Republic) that allows for high ongoing costs under a SIT-SUPP control strategy. Moreover the Israeli domestic market is often over flooded because of restricted access to the Gulf market and strong competition from Spain, Morocco and South Africa for the European market. The only comparative advantage for Israel would be to sell fruit to new markets in North America or Asia which require fly-free status and that the SIT-SUPP option can not provide.

Among the countries and territories included in this study for the SIT-SUPP option, Lebanon produces the highest benefit to cost ratio (27.3). However, as will be discussed further on, this economic return is lower compared to the figure obtained under the SIT-ERAD option. Although Lebanon has a well-developed Gulf export market it has also a large production area compared to the non crop area. As for Israel, the ongoing costs for the SIT-SUPP option are high. The Palestinian Territories have also a high B/C ratio (9.2), however, it is the lowest due to its small and undiversified fruit industry. Mainly citrus is grown which is normally the crop with the lowest price in the market. Also comparatively lower yields are produced due to poor agricultural practices. Although the domestic market is smaller than Israel, Jordan, Lebanon and Syrian Arab Republic the demand for stone, pome and subtropical fruits is still relatively high (ca 25 000 tonnes/year). At present most fruit in the Palestinian Territories other than citrus is imported from Israel and the Gulf countries. Exports of citrus to the Gulf countries and Western Europe is a common practice giving the present export potential to countries not requiring fly-free status of ca 37 000 tonnes/year.

The benefit to cost ratio obtained for Syrian Arab Republic (18.2) under a SIT-SUPP option is quite attractive but lower than Lebanon (27.3) and Jordan (22.5). Syrian Arab Republic has by far the largest fruit production area (2.7 the size of Israel which is the second largest) but the lowest fruit yields. Also the export market is almost non-existing and in the short term the benefits obtained by export market gains are quite limited compared to other countries in the region with a more solid infrastructure. Potential benefits from a fly-free market are quite small thus the comparative advantage that the SIT-ERAD option could provide is not substantial.

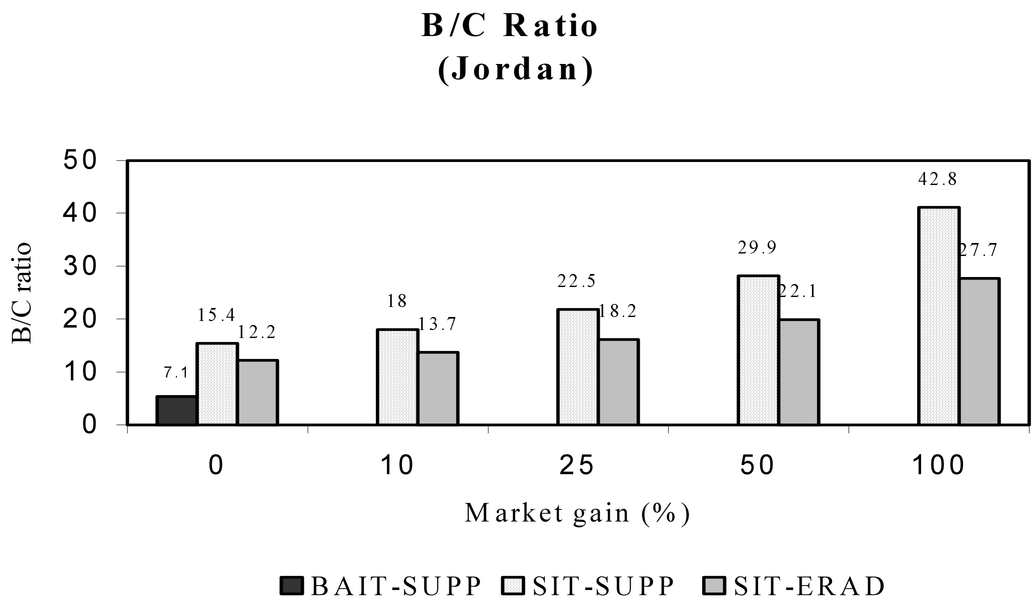

Figure 17. Benefit to cost ratio for Jordan for a range of market gains.

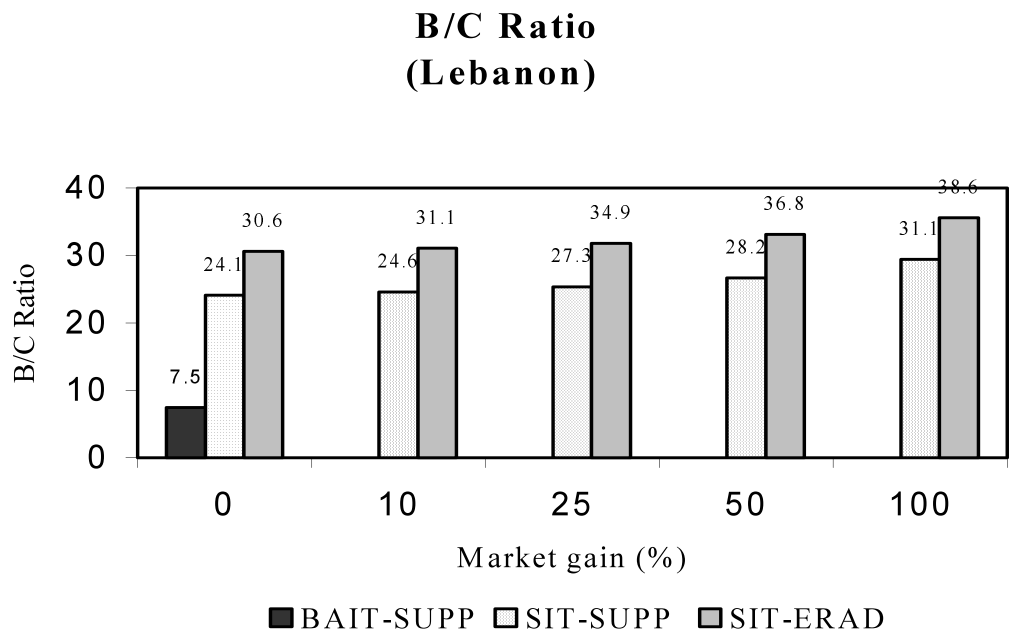

Figure 18. Benefit to cost ratio for Lebanon for a range of market gains.

4.2.2.3. SIT-ERAD

For the region the SIT-ERAD option produces the highest economic returns in a 14-year time frame although the difference compared to SIT-SUPP option is small. Even when SIT-ERAD is a more extensive and intensive control option during the first seven years (during the eradication phase), the overall costs are less than the two other options. As explained previously once fly-free status has been reached the SIT-ERAD option has substantially lower

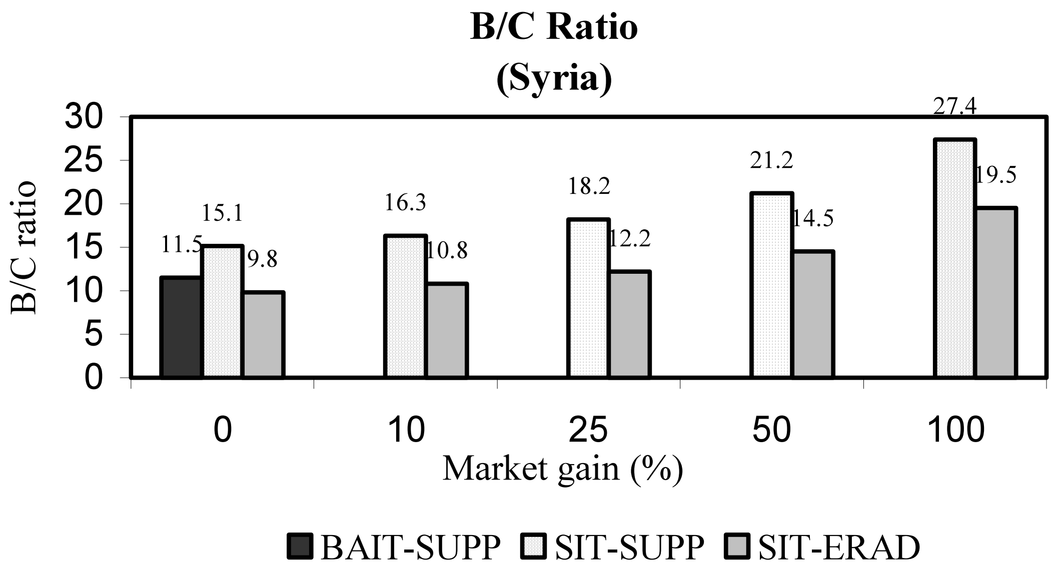

Figure 19. Benefit to cost ratio for Lebanon for a range of market gains.

ongoing costs than the other two control options (Figure 9). Furthermore, this option produces the highest cumulative gross benefits. Even when high value markets requiring fly-free status can only be accessed after eradication has been achieved, a 14-year time frame allows for full market gain to be obtained in each country and the region. Syrian Arab Republic, which according to the eradication strategy is the country were fly-free status comes last, would start market gain in years 6 and 7 and would obtain full gain by years 11 and 12. For this specific project, the SIT-ERAD option is US $47.6 million less expensive than the SIT-SUPP option and the accumulated net benefits of SIT-ERAD are greater by US $187 million (Figure 13).

Another important consideration is that for the region, based on present export quantities and assuming a 25% market gain, the potential export market requiring fly-free status is ca. US $35.4 million per year. The only control option that benefits from this market is SIT-ERAD.

On a country basis, the B/C ratio, using a 25% market gain is 20.8 for Israel, 8.5 for the Palestinian Territories, 18.2 for Jordan, 34.9 for Lebanon and 12.2 for Syrian Arab Republic (Table 15, Figures 15, 16, 17, 18 and 19).

As mentioned before, on a country basis, the SIT-ERAD option is the dominant control strategy for Israel and Lebanon. SIT-ERAD is performed in these two countries at a lower cost than SIT-SUPP because they have relatively smaller non-productive areas classified under non-host areas or other areas. Israel and Lebanon have comparatively greater commercial fruit producing areas than the other countries. The largest share of costs for the SIT-ERA option will be for the commercial fruit areas during the eradication process. These costs will fall substantially once eradication has been achieved. As mentioned before these countries will have higher ongoing costs due to the size of its fruit production area if the SIT-SUPP option is used.

Lebanon produces the highest returns, since it has, together with Israel, the most productive fruit industry. Currently in 22 000 hectares of medfly fruit hosts Lebanon produces ca. 503 000 tonnes of fruit whereas the Palestinian Territories in around the same surface

(19 600 ha) produces only 280 000 tonnes. Jordan in 34 000 hectares produces 375 000 tonnes and Syrian Arab Republic in 120 000 hectares (5.4 times the area in Lebanon) produces 1 081 000 tonnes (only 2.1 times more than Lebanon). Lebanon is producing more fruit then most Middle East countries per unit area in a relatively small area which results in the best benefit to cost relationship. Israel produces also high returns (second after Lebanon), since its fruit industry is the largest and traditionally most export oriented. The comparatively lower figure for Jordan (18.2) is a result of this country having a smaller fruit industry and higher eradication costs than Lebanon and Israel mainly due to its much larger area, especially the one classified under the category of other host areas (ca. 1303 sq km for Israel *vs* 4545 sq km for Jordan), in which costs are high and returns are low. The same applies to Syrian Arab Republic apart from the fact that fruit yields are the lowest of the countries and territories included in this study.

4.3. Other economic indices

For the three alternative control options, the pay back period is obtained in the first year. This reflects the effectiveness of the control options and the high value of the production being saved compared to the costs of the control options. The damage caused by the medfly to fruit production can be reduced to below economic levels in one production cycle.

The internal rate of return (IRR) and the return on equity (N/K) are not an issue in this study considering that the flow of costs and benefits have positive values from year one. This is because it is not anticipated to build a fruit fly factory but to purchase flies from existing factories, or from new privately financed factories.

4.4. Environmental impact

Although the total indirect damage of medfly control (ca. US $38.6 million/year) has been included as a benefit to estimate the economic indices for SIT-SUPP and SIT-ERAD control options, it is worthwhile to present a short individual economic assessment of pesticide use.

A regional implementation of BAIT-SUPP, SIT-SUPP or SIT-ERAD programs would reduce by at least 2.5, 5.0 and 6.4 times, respectively, the amount of malathion and other organophosphates sprayed into the environment. For a 14-year project, using the BAIT-SUPP option, 1605 tonnes of malathion would be sprayed, with 818 tonnes planned for the SIT-SUPP option and 638 tonnes for the SIT-ERAD option. Compared to 4100 tonnes of organophosphates that would be sprayed if current control practices persist.

Furthermore, in the region (Israel, the Palestinian Territories, Jordan, Lebanon and Syrian Arab Republic), the current control program will spend US $109 million on pesticide application in 8 years (standard time used for comparison) and US $309 million (US $38.6 million/year) in damage from secondary pest outbreaks, reduced pollination by bees, reduced honey production and treatment for human intoxication. The total direct and indirect cost of pesticide use amounts to US $418 million (US $109 million + US $309 million) in an 8-year period. Compared with US $19.2 million for pesticide in the post-suppression phase of the SIT-SUPP option and with none in the fly-free phase of the SIT-ERAD option, this results in an estimated return of US $399 million (US $418 million — US $19.2 million) for SIT-SUPP and of US $418 million (US $418 million — US $0 million) for SIT-ERAD in a eight year time period. Even if these figures are underestimated due to the scarce information available, the amount of money that could be saved by implementing any

very significant. Other indirect benefits, which are difficult to assess, also occur, such as lower insecticide residues in fruit for human consumption and in the environment for protection of wildlife. In the case of water, a very limited resource in the Middle East region, consumption may remain the same or increase if fly-free areas establish. Reducing crop losses obviously reduces losses in water, fertilizer and labour currently expended. Therefore, greater efficiency can be achieved and water consumption level maintained or reduced.

5. CONCLUSIONS

Any of the three area-wide control options analysed produce significantly higher economic returns than the conventional medfly control methods. The lowest figure obtained was a return of US $7.1 for each dollar invested. This was for the BAIT-SUPP option in Jordan. This reflects the effectiveness of the area-wide control options and the high value of the production being saved. Any of the area-wide options can reduce the damage caused by the medfly to economically insignificant levels in one production cycle.

The BAIT-SUPP option might not be sustainable in the long term because of the long term increasing costs, decreasing gross benefits and lack of comparative advantages. This is being experienced in Israel where a BAIT-SUPP program has been in operation for more than 32 years.

On a regional basis for a 14-year project the SIT-ERAD option is economically only slightly more attractive than the SIT-SUPP option.

Strengthening phytosanitary and in particular the quarantine infrastructure within the region for both plant and animal health programmes is an indirect benefit associated with the SIT-ERAD option. While it is difficult to assess the impact of reducing the introduction of exotic pests to the region, this benefit should be seen as an important additional advantage for this control option.

However, the SIT-ERAD control option has a higher level of uncertainty when considering political and social instability in the region. Access to high value fly-free export markets (United States, the Far East, etc) depend, not only on maintaining a fly-free phytosanitary status but also on a proper and strong infrastructure for storage, transportation and commercialisation. Keeping the region clean from medfly will require high organizational levels and collaboration among the countries and territories involved. Furthermore, official and/or private investment on such infrastructure will depend on social and economic stability in the region.

On the other hand the SIT-SUPP is a low risk option considering that its implementation can be done on an area or country basis and that no major additional infrastructure is needed to export the products to the traditional markets in North Europe, the Persian Gulf and Arab countries (not applicable to Israel in the case of the Persian Gulf and Arab countries). In addition, following this approach in combination with post-harvest measures does not preclude the export of fruit to medfly-free countries. A possible approach for an area-wide medfly control program in the region would be to start with a SIT-SUPP programme and as the political and institutional infrastructure develops in the region, the suppression program could eventually be upgraded to an eradication program.

Any of the SIT options analysed would produce significant benefits for the environment. For the whole region, in monetary terms and in a 14-year project, the amount that would be saved from avoiding indirect damage (secondary pest outbreaks, reduced pollination by bees, reduced honey production and treatment for human intoxication) would be at least US $309 million. In terms of insecticide use (organophosphates) any of the SIT options would reduce at least by five fold the amount of insecticide sprayed into the environment.

Eliminating the use of insecticides to control the medfly and the risk of medfly introductions to fly-free countries would result in the production of an improved product with better opportunities to compete in the traditional export markets and also in more discriminating “insecticide-free” and “pest-free” markets that pay a higher price for better quality fruits.

Being medfly the key pest for the major fruit crops in the Middle East, medfly SIT control could be an important step towards developing an organic fruit production in the Middle East countries without the need for medfly eradication.

The spreadsheet model used to assess the economic returns of the three control options is flexible enough to test any desired change in the main inputs and compare the outcomes of different scenarios. Based on this, a generic model for the economic analysis of area-wide fruit fly control options has been developed and is available upon request. A model of this nature is a very useful tool in terms of time saving and analysis of different scenarios for future fruit fly economic studies.

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