EIM SMALL BUSINESS RESEARCH AND CONSULTANCY

Study on a European Union wide regulatory framework for levies on pesticides

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EIM
Ruud Hoevenagel
Edwin van Noort

Haskoning
Rene de Kok

EIM / Haskoning
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Contents

1 Introduction

1.1 Background

It is generally acknowledged that the use of pesticides[1] has large benefits to farmers and society[2]. For example, pesticide use has been one of the major factors in improving efficiency in agriculture. Without these products, pest losses would make specialised crop and livestock production systems impractical. Estimates in the United States have indicated that the use of pesticides has been responsible for about one-fifth of the gain in productivity since the second World War. Moreover, it has been estimated that there would be a substantial reduction in crop output, about 25%, if pesticides would not be used anymore on farms in the United States (see Szmedra, 1991). Next to securing crop output and enabling specialisation, the use of pesticides has made it possible to fulfil the many critical consumer wishes with respect to agricultural products, such as the demand for impeccable red apples.

Notwithstanding these positive qualities, the present use of pesticides in agriculture also causes negative environmental effects (see Reus et al. 1994). In general, during and after application of pesticides a substantial amount of it ends up in soil, ground- and surface water or air. The presence of pesticides in these domains may constitute considerable negative effects to ecosystems and human health. For example, human health may be effected by pesticide residues on food and in drinking water and by direct exposure during application, while ecosystems may be effected by a loss of biodiversity. In fact, the use of pesticides in agriculture can affect wildlife both directly, through accidental poisoning, and indirectly, by depleting the food chains (see RSPB, 1998).

The above-mentioned negative environmental and health-related effects of the use of pesticides in agriculture demands for an effective policy to reduce the use of those pesticides which are the most harmful. Such policies have been initiated, both at the level of the individual Member States of the European Union and at the level of the European Union itself.

Policies initiated in the Member States differ (see Reus et al, 1994; Oppenheimer Wolff & Donnelly, 1996; DHV, 1998). In Denmark and Sweden, for example, a levy on pesticides has been introduced in a way to change the farmer's behaviour with respect to using pesticides. Moreover, these countries, together with France and the Netherlands, have initi-

[1] This study deals with the plant protection products which are covered by Council Directive 91/414/EEC. These products are mainly used in agriculture and usually referred to as pesticides. Yet, in EU legislation pesticides are divided into plant protection products and biocides. Hence, when the word 'pesticides' is used in this report, it should be recognized that the plant protection products are meant as covered by Council Directive 91/414/EEC.

[2] The latter has been challenged by Waibel and Fleischer (1998), who have monetarized the social costs and benefits of German pesticide policy. Their results seem to indicate that the use of pesticides in agriculture impose a net social loss to German society. It should be mentioned, however, that the results of Waibel and Fleischer have been criticized by the scientific world.

ated so-called *National Plant Protection Programs* to achieve a reduction in the quantity of pesticide used in the agricultural sector. In contrast, reductions in the use of pesticides in Germany and Italy to a large extent are achieved without government intervention (see Oppenheimer Wolff & Donnelly, 1996).

In the European Union the key objectives with regard to the use of pesticides have been set in 1992 in the *5th Environmental Action Program* (FEAP). The ultimate aim of FEAP is to "transform the patterns of growth in the Community in such a manner that the path to a sustainable future can be followed". With respect to the use of pesticides FEAP targets a decrease in the input of chemicals to the point that none of the basic natural processes indispensable for a sustainable agricultural sector are affected. More specifically, a significant reduction in the use of pesticides alongside a conversion to methods of integrated pest management, mainly in areas which are important for nature conservation, have been set as targets up to the year 2000.

At present, Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the internal market is probably the most prominent regulation of the European Union with respect to pesticides[3]. Whereas administrating Council Directive 91/414/EEC will decrease the number of active ingredients on the internal market, as well as the number of individual pesticides, full implementation is expected to take quite some time. According to Oskam et al. (1997) it is very unlikely that the target of full implementation in the year 2003 will be reached given the current working progress. In fact, estimates indicate that it may well take some 20 years before the full impact of Council Directive 91/414/EEC control over pesticides in the European Union can be achieved.

Given the expected implementation problem, and the fact that administrating Council Directive 91/414/EEC will only ensure specified safety standard for pesticides without directly affecting the quantities used, there seems a need to broaden the current European Union policy on pesticides to meet the targets as set in FEAP.

In this regard, DG-XI has initiated a long-term project in co-operation with the Dutch Ministry of Housing, Spatial Planning and Environment, aimed at developing and evaluating new strategies for a future European Union plant protection policy. This project consisted of two phases. The first phase was concluded in 1994 and resulted in two reports: *Towards a future EU plant protection product policy* (Reus et. al., 1994) and *Pesticide use in the EU* (Brouwer et. al., 1994). After a workshop, held within the same year, it was decided that more specialised investigations were required to address the different problem areas identified in this phase of the project.

3 Council Directive 91/414/EEC is intended to harmonize the pesticides registration systems now in existence in the 15 Member States. It establishes common rules which are to be applied in approving – or rejecting – active ingredients in plant protection products. These rules include health and environment-related criteria set forth in the so-called Uniform Principles.

The 'terms of reference' for the studies that encompassed the second phase of the project related to the possibilities for an additional plant protection policy in the European Union, defined as additional to the present EU legislation, in particular Council Directive 91/414/EEC. Recently, Oppenheimer Wolff & Donnelly (1997) have provided a synthesis report of these studies. In May 1998 a workshop was held in Brussels in which the results of these studies were discussed among 125 scientists and policy makers in the European Union (see DHV, 1998).

In some of these studies a levy on pesticides was regarded potentially effective and efficient in reducing the use of (harmful) pesticides in the European Union. For example, in the study of Oskam et al. (1997, p. 173) the potential usefulness of a levy on pesticides was judged as 'good'. It should be noted though that this judgement has a somewhat limited scope: i.e., when compared to other potentially useful policy instruments, such as speeding up the review programme of Council Directive 91/414/EEC, the potential effectiveness of a levy is regarded moderate by Oskam et al. (1997, p. 199).

Acknowledging the potentially usefulness of a levy to reduce the use of (harmful) pesticides in the European Union, the main economic, environmental and health-related effects of such a levy should be investigated thoroughly before some EU wide regulatory framework for the taxation of these products can be decided on. To a large extent, the costs of the levy will be beard upon by the farmers, manufacturers and industry, whereas the benefits will mainly result to society by means of a cleaner local and regional environment. Important questions which need to be answered, are:

- what would be the impact for the farmers?
- what would be the impact for manufacturers and industry?
- what would be the impact for employment in Europe?
- what would be the administrative costs of the levy?
- what would be the benefits to the environment?

Basically, the introduction of a levy on pesticides could be justified, if the benefits exceed the costs. When this is the case, a best working EU wide regulatory framework for the taxation of pesticides should be designed.

It is evident that a quantification of the benefits to the environment are difficult, if not impossible, to obtain. The available valuation methods which can be used to calculate these benefits are still debatable. Also with respect to a quantification of the costs severe problems will occur. Consequently, conducting the 'ideal' comprehensive cost-benefit analysis on the introduction of a levy on pesticides should be regarded as imaginary. Nevertheless, this study aims at answering the first question stated above: on the economic effects for the farmers involved. Moreover, the potential environmental benefits of a levy will be discussed qualitatively.

In addition, the study will discuss the contours of a best working EU wide regulatory framework on the taxation of pesticides by answering questions, such as:

- what would be the most efficient imposition points for the levies?
- what would be the most effective charge basis?
- what would be the optimal charge rate?
- what would be the best reimbursement system?

Whereas the above-stated questions on a best working regulatory framework are clear, answers are not easily to provide since there is little experience with respect to a levy on pesticides. Of the fifteen Member States of the European Union only Denmark and Sweden have some practical evidence on this subject.

1.2 Objective of the study

Given the distinct character of a European Union wide levy on pesticides and the little experience in the individual Member States on this subject it seems justified to represent such a levy as a kind of 'grey box': with respect to its economic effects, with respect to its environmental effects and with respect to a best working regulatory framework. As a consequence, the key objective of this study will be *to enlighten this grey box.*

Such a process of enlightenment is warranted, given the expected environmental improvements in the European Union and the need to harmonise the internal market on this subject: i.e., in case a levy on pesticides would be defined by the Commission, the basic elements of this levy should hold for the whole European Union to avoid discrimination between the Member States. Note that a European Union wide levy on pesticides would be in line with FEAP which proposes to broaden the range of policy instruments from direct regulation towards economic instruments.

The study will evaluate and quantify, to the extent possible, the main economic and environmental effects of a levy on pesticides. Thereby the concept of pesticide chains will be used: i.e., the effects of a levy will be analysed for a specific type of pesticide, a specific type of crop, and a specific region. The underlying motives for using this kind of methodology will be explained in chapter 2.

Besides this, the study aims at producing results which should allow the Commission to define an EU wide regulatory framework on the taxation of pesticides, if necessary, alike the one on energy products (see CEC, 1997). This means that developing a best working system for an EU wide levy on pesticides forms an important part of the study.

Given the above-stated objectives of the study, the following research questions will be answered in this study:

1. In what respect is the experience presently available in the Member States on the use of pesticides useful for developing an EU wide regulatory framework for levies on pesticides?
2. What would constitute the ideal EU wide levy on pesticides?
3. Are there potential bottlenecks, if any, which could hinder the introduction of such a levy on pesticides?
4. What are the main economic and environmental effects of an EU wide levy on pesticides?
5. What would constitute the ideal EU wide regulatory framework for levies on pesticides?

These research questions will be dealt with successively in this study. The first, second and third question will be analysed in chapters 2, 3 and 4. The fourth research question will be answered in chapter 5, and the last research question - 'What constitutes the ideal EU wide regulatory framework for levies on pesticides?' – will be tackled in chapter 6.

1.3 Structure of the report

This section presents the main subjects of the various chapters in the study.

Chapter 2 deals with the scope and methodology of the study. As for the scope, the study will be directed to the use of pesticides in agriculture. The key motives for this restriction are elaborated. In this regard, section 2.2 provides insights into the use of pesticides in the agricultural sector of the EU. As for the methodology, the concept of pesticide chains is explained in section 2.3.

Chapter 3 discusses the usefulness of market-based instruments to reduce pesticide use in agriculture. In this respect, section 3.2 compares six types of policy instruments to influence farmers' behaviour on using pesticides. Section 3.3 goes into the usefulness of market-based instruments to reduce pesticide use, while section 3.4 defines the ideal case with respect to a levy on pesticides. After this, section 3.5 reviews the present situation in the individual Member States on reducing pesticide use by means of a levy. In the final section of this chapter, conclusions will be drawn with reference to the first three research questions stated in section 1.2.

Chapter 4 introduces the model that has been developed to analyse the main economic and environmental effects of an EU wide levy on pesticides. Before describing this model, section 4.2 proposes a classification of the pesticide used in agriculture on the basis of their effects to the aquatic environment. This classification will be used in designing the levy systems for the various pesticide chains in chapter 5. After a brief description of the underlying theoretical framework in section 4.3, an economic model is defined in section 4.4. With this model, topics, such as the achieved reduction in the use of pesticides, the increased costs to the farmers and changes in the gross margin of farmers, can be dealt with. Finally, in section 4.5 the results of a review on the price elasticity's of demand of pesticides is presented.

Chapter 5 analyses the main economic and environmental effects of a levy on pesticides for the pesticide chains selected. In the first section of this chapter the choice for selecting the various chains will be motivated. The next section considers the information which is needed to use the economic model satisfactory. As this information is not always available, various assumptions had to be made. Section 5.3 will elaborate on these assumptions. Section 5.4 presents the outcomes of the various pesticide chains. Each chain will be presented in a pre-determined format. In the final section of the chapter conclusions will be drawn with reference to the fourth research question stated in section 1.2.

Chapter 6 deals with designing an EU wide regulatory framework for levies on pesticides. Using the existing regulatory framework on the taxation of energy products, five consequential elements have been selected: i.e., the products involved, the charge base, the charge rate, the imposition points and the allocation of the revenues. These elements are discussed in separate sections. By using the information of the preceding chapters, propositions will be formulated for each consequential element. Consequently, in section 6.7 a best working system for an EU wide regulatory framework for levies on pesticides will be suggested.

Finally, chapter 7 presents the key conclusions of the study.

2 Scope and methodology

2.1 Defining the study

Pesticides are being used in various economic sectors, such as agriculture (including forestry), transportation (railroads), industrial zones, parks and households (gardens). Among these sectors, agriculture is the major user. About 80 to 90% of all pesticides in the European Union are being sold to farmers (Brouwer et al., 1994). Given the enormous area which is cultivated by farmers in the European Union today, and thus the potential negative effects of pesticides to the environment (soil and water), it is only sensible to focus this study on the pesticide used in the agricultural sector.

The next definition of the study relates to the countries involved. Since one of the basic aims of this study is to sketch the contours of a European Union wide regulatory framework for levies on pesticides, the countries involved in this study are the Member States of the European Union. This means that both the desk-research and the pesticide chains are directed at these Member States.

The study will focus on the main economic and environmental effects of a levy on pesticides. The economic effects involved are directed to the farmers but can be aggregated to the agricultural sector. Economic effects at the national or the EU level cannot be analysed by the model developed in this study (see chapters 4 and 5). The environmental effects analysed will be directed to the aquatic ecosystems. Due to the character of the model, the effects described in this study will be biased to the economic side.

An important element of this study is that existing data have to be used. Therefore, desk-research and expert-interviews are the basic ingredients of this study. With respect to the latter, experts were contacted in a way to design the outline of this study more clearly and to collect the data for the various pesticide chains selected. (The procedure used to collect these data is explained in Annex I.)

The remaining sections of this chapter deal with three topics. First, section 2.2 provides some insight into the use of pesticides in the Member States of the European Union, based on sales figures. Second, section 2.3 discusses some key factors behind the use of pesticides in order to gain more understanding in the potential effectiveness of a levy on pesticides. Third, section 2.4 elaborates on the concept of pesticide chains: a concept which forms an important element in this study. Finally, the major conclusions will be drawn.

2.2 The use of pesticides in agriculture

It is difficult to gain a clear insight in the use of pesticides in the agricultural sectors of the Member States of the European Union. The information needed – the use of pesticides at the farm, split up by type, frequency and quantity – is only available in some Member States and for a restricted number of farms. For example, in the Netherlands a small preselected group of farmers keep detailed records of these issues. In the European Union, information is collected for a relatively large group of farmers – about 60.000 – on the yearly amount spent on pesticides (this is the so-called *Farm Accountancy Data Network*). Whereas this information is interesting with regards to economic aspects, such as the share of pesticide costs in the output or in the variable costs, the information is less useful with regards to environmental aspects: i.e., the amounts spent on pesticides do say little about the types and quantities used.

As the information needed is lacking for the whole European Union, the use of pesticides in the agricultural sectors of the Member States has been estimated on the basis of sales figures (see, Brouwer et al., 1994). Whereas the correlation between sales figures and pesticide use will be high and positive, the correlation between sales figures and environmental effects of pesticide use will be less evident. As an illustration of the range of quantities involved, Table 2.1, provides an overview of pesticide use in the agricultural sectors of the Member States for the period 1990-1993.

Table 2.1 Pesticide use in agriculture: 1990 - 1993 (in tons active ingredients)

	1990	1991	1992	1993
Greece	19.923	16.369	12.814	9.260
Finland	2.037	1.721	1.404	1.279
Netherlands	18.835	17.306	15.921	11.585
Denmark	6.428	5.620	5.725	4.277
Austria	4.690	4.486	3.869	3.983
Germany	33.146	36.944	33.570	29.350
Italy	87.924	84.747	81.571	78.394
France	97.701	103.434	84.709	88.492
Sweden	11.008	8.007	8.693	8.915
Belgium	10.264	9.969	10.426	10.282
Portugal	9.337	9.355	6.117	9.426
Ireland	1.877	2.006	2.322	2.523
UK	23.592	24.662	23.800	33.240
Luxembourg	253	253	253	253
Spain	29.501	29.501	29.501	29.501
Total	356.516	354.380	320.695	320.760

Source: Brouwer et al. 1994.

In Table 2.2 the fifteen Member States of the European Union have been ordered according to their share in the use of pesticides for the year 1993. From this Table it can be seen that two Member States - France and Italy - accounted for more than half of all pesticide use in the European Union in 1993: 52%. The shares of these two countries remain almost the same in the period 1990 tot 1993: around 28% for France and 24% for Italy.

Table 2.2 Member States' share in the use of pesticide in the European Union: 1990 - 1993 (in %)

	1990	1991	1992	1993
France	27,4	29,2	26,4	27,6
Italy	24,7	23,9	25,4	24,4
U. K.	6,6	7,0	7,4	10,4
Spain	8,3	8,3	9,2	9,2
Germany	9,3	10,4	10,5	9,2
Netherlands	5,3	4,9	5,0	3,6
Belgium	2,9	2,8	3,3	3,2
Portugal	2,6	2,6	1,9	2,9
Greece	5,6	4,6	4,0	2,9
Sweden	3,1	2,3	2,7	2,8
Denmark	1,8	1,6	1,8	1,3
Austria	1,3	1,3	1,2	1,2
Ireland	0,5	0,6	0,7	0,8
Finland	0,6	0,5	0,4	0,4
Luxembourg	0,1	0,1	0,1	0,1

Source: EIM

Next to the two main users of pesticides in the European Union, three other countries – the United Kingdom, Spain and Germany – were responsible for another 29% of the total pesticide use in the European Union in 1993. Together, the five Member States accounted for 81% of total pesticide use in the European Union in 1993. The other ten Member States were responsible for the remaining 19%.

Even the smaller Member States with regards to the use of pesticides in the agricultural sector can be divided into two groups. The first group consists of Member States with an estimated share of pesticide use of about 3% each: the Netherlands, Belgium, Portugal, Greece and Sweden. The remaining five Member States of the European Union have an estimated share of pesticide use of about 1% each: Denmark, Austria, Ireland, Finland and Luxembourg.

The above-mentioned order, although somewhat dated, seem to imply that a majority of the pesticide chains selected should be directed to the dominant users of pesticides in the European Union: France, Italy, United Kingdom, Spain and Germany. The remaining pesticide chains could be directed at the other Member States of the European Union, with a preference for Belgium, Sweden, Portugal, the Netherlands and Greece.

Intensity and efficiency of pesticide use

Whereas the information displayed in Table 2.1 and 2.2 is illuminating, it is certainly not conclusive to design a European Union wide regulatory framework for levies on pesticides on. For that reason, more decisive standards are needed, such as the *intensity of pesticide use* and the *efficiency of pesticide use*. Table 2.3 presents estimates of both standards for the period 1993 to 1995.

Table 2.3 Intensity and efficiency of pesticide use in the Member States: 1993 - 1995.

	intensity of pesticide use (pesticide use in kg active ingredients per hectare)	*efficiency of pesticide use* (pesticide use in kg active ingredients per € 1000 crop production)
France	5.6	4.0
Italy	9.3	3.7
U. K.	6.4	5.0
Spain	2.3	2.3
Germany	2.6	2.4
Belgium	13.8	4.0
Sweden	1.2	2.2
Portugal	6.0	6.9
Netherlands	13.5	1.6
Greece	4.4	1.6
Denmark	1.7	2.2
Austria	4.0	2.5
Ireland	16.3 [a]	4.7
Finland	1.2	0.8
Luxembourg	4.4	6.7

a) Recent evidence suggests that this figure is far too high. A more realistic estimate seems to lie in the order of 5 to 8 kg per hectare.

Source: Oskam et al. (1997)

The *intensity of pesticide use* provides relevant information with respect to the potential negative effects to the environment. In general, a higher intensity will lead to a higher threat, as more pesticides are being used per hectare. From the second column of Table 2.3 it can be seen that Belgium, the Netherlands and Italy have a high intensity of pesticide use. In Belgium, for example, on average 13.8 kg active ingredients were used per hectare arable and horticulture land in the period 1993 to 1995. In the five dominant users of pesticides - Italy, France, the United Kingdom, Spain and Germany – on average 5.2 kg active ingredients were used per hectare arable and horticulture land.

The *efficiency of pesticide use* provides relevant information with respect to the potential effectiveness of a levy on pesticides. In general, a high efficiency of pesticide use, which relates to a small number in the last column of Table 2.3, may lead to a low effectiveness of a levy as the financial impact to the farmers will be small. From the last column in Table 2.3 it can be seen that Finland, Greece and the Netherlands have a high efficiency of pesticide use. In countries, such as Portugal, Luxembourg and the United Kingdom levying pesticides seem to have a greater financial impact to the farmers involved.

On the basis of the information on the intensity of pesticide use it seems necessary to include in the set of pesticide chains at least some crops which are cultivated in 'high intensity countries', such as the Netherlands and Belgium, and in 'low intensity countries', such as Finland, Denmark and Sweden. By the same token, the information on the efficiency of pesticide use suggests that chains from 'polar' Member States such as Finland and the United Kingdom or the Netherlands and Portugal should be included to get a clear view on the potential effectiveness of a levy on pesticides.

While the two standards in Table 2.3 are more decisive than the one in Table 2.1, all three of them have no direct relationship with the negative effects of pesticides to the environment. This is because not all active ingredients pose the same hazards to the environment. For example, the 13.8 kg active ingredients which are put on the arable and horticulture land of Belgium, on average, *could be* less harmful to the environment than the 5.6 kg active ingredients put on French arable and horticulture land.

The actual environmental hazards of pesticides depend on many factors, such as the quantities used, the equipment used, frequency of spraying, the type used , and the period of using the pesticides. To get a more informative insight into the environmental hazards of pesticides as well as into the potential effectiveness of a levy on pesticides, the concept of *pesticide chains* is introduced. Section 2.4 will elaborate on this topic. Before that, the next section discusses some key factors that determine the use of pesticides.

2.3 Decisive factors behind the use of pesticides

From Table 2.1 and 2.3 it can be seen that pesticide use differs across the Member States of the European Union. To a large extent these differences can be resolved to four groups of decisive factors, i.e.:

- agronomic factors;
- economic factors;
- policy factors;
- farm-related factors.

Agronomic factors

The group of agronomic factors include factors, such as the general weather and soil conditions in a country and the (corresponding) cropping pattern. These factors are important since they determine to a large extent the type of pesticide used and the dosage per hectare. In the Netherlands, for example, the intensity of pesticide use is high due to a large share of potatoes in the cropping scheme of farmers. Moreover, the maritime climate in the Netherlands generates good conditions for weed and fungi. Countries, such as Italy, France and Spain, use more insecticides as their subtropical climate generates good conditions for insects.

It should be noted that agronomic factors are difficult to influence, although the CAP has some effect on the choice of crops. A European Union wide regulatory framework for levies on pesticides should take into account the countries' specific agronomic circumstances in order to be acceptable.

Economic factors

The group of economic factors include factors, such as the crop intensity, the price of alternatives to pesticides and the efficiency of pesticide use. In Belgium, crop intensity is relatively high due to a shortage of agricultural land. A high crop intensity usually results in a high use of pesticides to counteract crop-specific weeds, fungi, etceteras. A high efficiency of pesticide use usually also generates a high dosage of pesticides per hectare. In fact, the larger the difference between the pesticide costs and crop benefits, the less incentives there will be for the farmer to reduce his use of pesticides. Generally, the key criterion for the farmer is not the retail price of the pesticides but their agronomic effectiveness. Note that the price of crop protection is only a small item on the budget of the farmer, whereas the consequences of using ineffective pesticides are huge.

Compared to the above set of agronomic factors, economic factors can be influenced by the Commission. For example, the price of pesticides can be increased by means of a European Union wide levy, whereas the benefits of the crops can be influenced by the CAP. The crop intensity in a country is, however, more difficult to influence.

Policy factors

The group of policy factors encompasses the set of governmental instruments which are used to reduce the use of pesticides. Types of instruments that could be used include regulation, information, persuasion, arrangements, technological improvements and economic incentives (see chapter 3). Which instruments are actually used depends to a large extent on the political climate in a country. The intensity of the activities which arouse from the government often depends on many factors, such as the political power of the agricultural sector, the potential conflicts between nature and agriculture in a country, but also on the country's dependency on groundwater (e.g. Denmark).

Farm-related factors

It is well known that farmers living in the same region and having the same cropping pattern, can have large differences in their use of pesticides. These differences can be linked to farm-specific factors and farmer-specific factors. With respect to the farm-specific factors, Buurma (1997) claimed that a farm's history in relation to the number of crop failures could be an important decisive factor. Sometimes, unforeseen agronomic factors at the farm level could also be influential, such as the cultivation of apples under windbreaks. With respect to the farmer-specific factors, the attitude of the farmer to the use of pesticides could be important: i.e., to what extent is he interested in alternatives to pesticides?, and how effective is the communication between the agricultural advisory service and the farmer?[4] Answers to these kind of questions will certainly illuminate the differences in pesticide use at the farm, and at the same time constitute the materials for an effective European Union wide regulatory framework for levies on pesticides.

The above set of decisive factors stands behind the use of pesticides at the farm (see also Produce Studies, 1996). It should be noted that the price of pesticides is only one of these factors. Moreover, as the price of crop protection is a relatively small item on the budget of the farmer one should be realistic rather than optimistic with respect to the potential effectiveness of a European Union wide levy on pesticides.

2.4 The concept of pesticide chains

Analysing the effects at the level of the farms

Ideally, the potential effects of a levy on pesticides should be analysed at the level of the farms: i.e., which reactions can be expected from farmers when the price of some of the pesticides they use will be, say, doubled? Will, and can farmers use the pesticides levied more efficiently? Will, and can they turn to mechanical or biological alternatives? Will, and can they turn to less levied pesticides? Or, will they simply pay the levy? To get a good overview of the possible reactions, in-depth interviews with a reasonable number of farmers are needed, whereby the interviews preferably are divided by type of pesticides, intensity and efficiency of pesticide use and agronomic regions in the European Union. Whereas this kind of information would be the most informative for this study, it would also be quite laborious and expensive to collect. Therefore, a different route had to be taken to collect the relevant data.

Analysing the effects at the level of Member States

Another possibility, almost contrary to the one above, and followed by Oskam et al. (1997, p.136), is to analyse the potential effects of a levy on pesticides at the level of the Member States. Based on a review of the relevant literature, Oskam et al. (1997) assumed a price elasticity of - 0.4 for all pesticides in the Member States and analysed the overall effect of a price increase of 10%. By using a very simple calculation, a 4% reduction of pesticide use was established in the European Union. After deducing certain administration costs also the net revenues of a levy of 10% was calculated.

4 Personal communication of Braat, 1998.

This route, followed by Oskam et al., has only illustrative significance. For example, it is unclear whether one overall price increase of 10% would be the most effective for reducing the most harmful pesticides.

Analysing the effects at the level of pesticide chains

In this study a middle course of aggregation is adopted for analysing the economic and environmental effects of a levy on pesticides: i.e., the analysis will be done at the level of pesticide chains. An example of such a pesticide chain is *fungicides in cucumbers in England and Wales.* Hence, a pesticide chain consists of a certain type of pesticide (e.g. fungicides, herbicides, insecticides), a certain crop in which the pesticide is used (e.g. cucumbers, potatoes, winter wheat) and a certain region (e.g. England and Wales, the Netherlands).

Basically, the concept of pesticide chains forms a nice alternative to the ideal case of interviewing a representative number of farmers. By using the concept of pesticide chains it is expected that enough detailed information on the types of pesticide used, their environmental hazards, their prices, and possible alternatives, can be collected in order to provide reliable estimates of the economic and environmental effects of a levy[5]. Moreover, by using this concept it is expected that the outcomes of the pesticide chains are informative enough to design a European Union wide regulatory framework for levies on pesticides on[6]. Therefore, the outcomes of the pesticide chains should not be too specific, but in one way or another be generalised to a higher level of aggregation. For example, in the case of cucumbers in England and Wales, the outcomes should preferably be generalised to the horticultural sector in England and Wales.

2.5 Conclusions

This study is defined to the use of pesticides in the agricultural sectors of the Member States of the European Union. The focus of the study will be on the main economic and environmental effects of a levy on pesticides.

In order to come up with reliable estimates of these effects the concept of pesticides chains is introduced in this study. A pesticide chain consists of a certain type of pesticide, a certain crop in which the pesticide is used and a certain region in the European Union. By using this concept it is expected that, on the one hand, enough detailed information on the types of pesticide used, their environmental hazards, prices, and alternatives can be collected in order to gain reliable outcomes, while, on the other hand, it is expected that

5 In order to come up with reliable outcomes, the concept of pesticide chains demands much information. In chapter 5 the exact information needs are displayed.

6 It is not claimed here that an European Union wide framework for levies on pesticides should be necessarily differentiated to the level of pesticide chains. In fact, this is only one of the options. In Chapter 6 this issue will be elaborated on.

the outcomes are broad enough to design a European Union wide regulatory framework for levies on pesticides on.

Therefore, the outcomes of the pesticide chains should not be too specific. From the other sections in chapter 2 other demands on the pesticides chains have emerged. For example, from Table 2.3, which presented information on the Member States' share in pesticide use in 1993, it is proposed that a majority of the pesticide chains should be directed at the dominant users of pesticides in the European Union: France, Italy, United Kingdom, Spain and Germany. From Table 2.4, which displayed information on the intensity and efficiency of pesticide use, it is proposed to include in the final set of pesticide chains at least some crops which are cultivated in 'high intensity countries', such as the Netherlands and Belgium and 'low intensity countries', such as Finland and Sweden. By the same token, the information on the efficiency of pesticide use suggests that chains from 'polar' Member States as Finland and the United Kingdom or the Netherlands and Portugal should be selected in order to get a clear view on the potential effectiveness of a levy on pesticides.

With respect to the potential effectiveness of a levy on pesticides it was concluded that one should be realistic rather than optimistic. This conclusion was based on the fact that a large bundle of decisive factors stands behind the use of pesticides at the farm, the price of pesticides only being one of them.

Finally, it is concluded that a European Union wide regulatory framework for levies on pesticides should take into account the countries' specific agronomic circumstances in order to be acceptable.

3 Usefulness of market-based instruments to reduce the use of pesticides

3.1 Introduction

In the last two decades the usefulness of market-based instruments to reach a sustainable development has been acknowledged by both the European Union and the OECD. For example, in order to arrive at its environmental aims the 5^{th} *Environmental Action Program* proposes to broaden the range of policy instruments from direct regulation towards financial regulation through the use of market-based instruments (see CEC, 1992). Moreover, in December 1995 the European Council of Madrid concluded that 'in order to exploit the job-creation potential of environmental protection, these (environmental) policies should - to a greater extent than at present - rely on market based instruments, including fiscal ones'.

The increased interest in market-based instruments as a tool for reaching environmental aims has several backgrounds. Motives which have stimulated each other. The most important developments are:

- theoretical improvements in the field of environmental economics on the effectiveness and efficiency of market-based instruments;
- policy changes in the European Union with respect to reaching environmental goals, such as a deeper interest into the strength of the market, more interest in ways to prevent environmental pollution rather than to clean-up pollution (end-of-pipe) and more interest in the cost and benefits of policy measures (efficiency besides efficacy);
- a certain lack of efficiency and perceived problems concerning the usefulness and maintenance of command-and-control instruments.

A reflection of the above developments can be found, for example, in OECD-surveys on the use of market-based instruments in the environmental policies of the Member States of the OECD (e.g. OECD, 1997). In these surveys, a wide range of market-based instruments have been investigated. Table 3.1 presents an overview of the situation in the *Member States of the European Union* for the year 1997.

From Table 3.1 it can be seen that a total of 182 market-based instruments were used in the Member States of the European Union in 1997 to reach a variety of environmental goals. The Member States have been ordered according to the total number of market-based instruments used: Denmark has the lead with 23 instruments, Luxembourg is the last with three market-based instruments. More than one-third of all 182 market-based instruments (i.e. 65) are being used in three Member States: Denmark, Finland and Sweden. In the five Southern Countries of the European Union - Greece, Italy, Spain, Portugal and France - a total of 43 instruments are being used (with a mean of 9). The other seven 'middle' countries of the European Union - Austria, Belgium, Germany, Ireland, Luxembourg, United Kingdom and the Netherlands - are responsible for the remaining 74 instruments (with a mean of 11).

Table 3.1. The use of market-based instruments in the Member States of the European Union in 1997.

Countries	D	F	S	B	N	G	F	P	A	S	U	I	I	G	L	*total*
	e	i	w	e	e	e	r	o	u	p	K	r	t	r	u	
Env. policies	n	n	e	l	th	r	a	r	s	a		l	a	e	x	
motor fuels	4	5	6	2	3	2	2	2	2	2	2	2	2	2	2	*40*
other energy prod.	3	2	4	3	2	1	3	-	2	1	1	1	1	1	1	*26*
vehicle taxation	2	1	2	2	2	1	-	1	2	1	-	2	2	2	-	*20*
agricultural inputs	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	*4*
other goods	6	4	1	4	-	-	-	2	-	-	-	-	-	-	-	*17*
direct tax provision	2	3	1	2	1	2	1	1	1	1	1	-	-	-	-	*16*
air transport	-	-	2	1	1	1	1	1	-	-	-	-	-	-	-	*7*
water	3	2	2	3	4	3	2	2	-	1	2	-	-	-	-	*24*
waste disposal and management	2	3	1	2	3	3	3	3	2	2	2	1	1	-	-	*28*
total	*23*	*21*	*21*	*19*	*16*	*13*	*12*	*12*	*9*	*8*	*8*	*6*	*6*	*5*	*3*	*182*

Source: OECD 1997

With respect to the various environmental policies, Table 3.1 shows that market-based instruments are mainly used for reaching environmental goals in the field of waste disposal and management (28 instruments) and for goals in the field of motor fuels and other energy products (together 66 instruments). It should be noted that only in the field of motor fuels all Member States of the European Union use one or more market-based instruments.

With respect to environmental policies in the field of agricultural inputs, Table 3.1 displays that only in the three Scandinavian Member States market-based instruments are used. One may wonder why such instruments are not being used more often in this field. Is it because these instruments are not useful here? Is it because other instruments are more effective? Is it because the agricultural policies of the Member States rely to a great extent on the CAP? Or, is it because agricultural lobbies prevent a widespread use of market-based instruments?

This chapter deals with the first two questions: on the usefulness of market-based instruments to reduce the use of pesticides in agriculture, in relation to other policy instruments. In this regard, section 3.2 reviews the various policy instruments to reduce the use of pesticides, market-based instruments being one group of them. Section 3.3 enters the discussion on the usefulness of market-based instruments with respect to reducing pesticides in agriculture. After this, section 3.4 sketches the contours of an ideal levy to diminish the adverse environmental effects of pesticides, together with some practical problems. The present situation in the Member States of the European Union with respect to reducing the use of pesticides by means of a levy is reviewed in section 3.5. Finally, in the last section of this chapter, conclusions are drawn with reference to the first three research questions stated in section 1.2.

3.2 Policy instruments to reduce pesticide use in agriculture

Oskam et al. (1997) have analysed the usefulness of 35 policy instruments to reduce the use of pesticides in agriculture. The instruments were divided into six groups (between brackets are the number of policy instruments analysed):

- regulation (7);
- information, persuasion and awareness (3);
- technological and institutional change (11);
- arrangements (2);
- market-based instruments (10);
- private law instruments (2).

Policy instruments in the field of *regulation* are still the most used in the European Union environmental policy area, despite recent statements and appeals for a greater use of market-based instruments. An example of a regulative instrument is Council Directive 91/414/EEC concerning the placing of pesticides on the internal market. Compared to regulative instruments, instruments in the field of *information, persuasion and awareness* have a voluntary basis. On the one hand, these instruments are used to support and facilitate the introduction of other policy instruments, such as regulatory ones, on the other hand, these instruments are used in a way to transfer new knowledge to the farmers. Examples include the training and educating of farmers with regards to integrated pesticide management. As for *technological change*, the role of the Commission is usually limited to (financial) stimulation, observation and monitoring. Policy instruments in this field are, for example, programs on resistant and sensitive cultivates, improvements in application technology and inspection programs. With respect to *institutional change,* the role of the Commission is more straightforward insofar as it concerns reforms of the CAP, such as abolishing the price support for cereals. Convenants in the field of pesticides, such as the 'Dutch Multi-annual programme on Plant Protection Products', are examples of *arrangements* between the government and the sector. *Market-based instruments* are usually used to create incentives for the farmer to change his/her behaviour in a more environmental-friendly way. Finally, an example of a *private law instrument* in the field of pesticides is a mandatory pesticides reduction clause in land lease contracts.

In order to evaluate and compare the above-mentioned policy instruments, Oskam et al. (1997) defined six criteria, namely:

- effectiveness;
- efficiency;
- acceptability;
- enforceability;
- institutional homogeneity;
- disturbance of income levels and property rights.

On each criterion a policy instrument could score '+++' (very high or very good), '++', '+', '+/-', '-' and '--' (very low or very bad). On the basis of these scores, Oskam et al. (1997) also provided a general judgement for each policy instrument.

Table 3.2 presents the results of Oskam et al. (1997; pp. 171-174) in a condensed way: i.e., in this Table only the general judgements of the 35 policy instruments are given. For example, of the seven policy instruments that belong to the group of *regulation*, four of them were rated by Oskam et al. (1997) with '++' (good), one of them was rated with '+' (moderate) and two of them were rated with ' -' (low).

Table 3.2 Evaluation of the usefulness of 35 policy instruments to reduce the use of pesticides

type of instrument	number of instruments	general judgements [a]	overall "order"	
arrangements	2	2 (++)	I	(2.0)
regulation	7	4 (++) , 1 (+), 2 (-)	II	(3.0)
technological or institutional change	11	3 (++), 4 (+), 3 (+/-), 1 (-)	III	(3.2)
market-based instruments	10	2 (++), 5 (+), 1 (o), 2 (-)	IV	(3.3)
information, persuasion and awareness	3	1 (++), 1 (+), 1 (-)	IV	(3.3)
private law instruments	2	1 (+), 1 (o)	VI	(3.5)
total	35			

(a) '++': high/good, '+': moderate, '+/-': variable between + and -, 'o': neutral. '-': low/bad.

Source: Oskam et al. (1997)

In the last column of Table 3.2 the general judgements of the policy instruments have been standardised in a way to order the six groups of instruments with respect to their usefulness to reduce the use of pesticides in agriculture. The process of standardisation consisted of three steps: first, each qualitative statement was given a number: '+++' got a 1, '++' got a 2, etceteras, second, the number of general judgements was multiplied with these numbers (for example, in the group of regulation the multiplication resulted in 4 x 2 + 1 x 3 + 2 x 5 = 21), finally, the result was divided by the number of policy instruments in the group: hence, the mean rating of the group of regulation was 3.

After applying the above methodology, it can be seen from Table 3.2 that policy instruments in the field of *arrangements* and *regulation* are considered by Oskam et al. (1997) to be the most useful with respect to reducing pesticide use in agriculture. *Market-based instruments* - which forms the core of this report - are ranked at the fourth place, alike *information, persuasion and awareness* and just after instruments in the field of technological and institutional change. The use of private law instruments is considered the least useful with respect to reducing the use of pesticides.

Whereas the above order is subjective in nature, debatable with respect to the methodology used, and dependent on the policy instruments included in the evaluation, it is interesting to note that the order in Table 3.2 corresponds to the one of a recent questionnaire on the usefulness of policy instruments for an additional EU wide policy on pesticides. This questionnaire was held for the purpose of the *second workshop on a framework for the sustainable use of plant protection product in the European Union* (DHV, 1998) and mailed to 52 scientists and policy makers in the Member States of the European Union; 24 of these people responded.[7]

One of the questions in the questionnaire related to a ranking of (stated) policy instruments (from most preferred to least preferred) with respect to four policy strategies:

1. a restriction of the use of highly hazardous pesticides;
2. an effective control of risks at use level;
3. a promotion of low input agriculture;
4. a reduction of overall use of pesticides.

For the purpose of this study, the results of the first and last strategy are the most interesting. They will be briefly presented below.

In order to restrict the use of highly hazardous pesticides (strategy I), respondents considered speeding up the review of Council Directive 91/414/EEC as the most effective, most politically acceptable and most enforceable. The second place was for area-based bans, the third place for a mandatory certification of operators, the fourth place for a restricted access to certain plant protection products, and the fifth place for voluntary certification and training of distributors and operators. Speeding up the review of Council Directive 91/414/EEC was also considered the most useful instrument for reaching an overall

[7] Five of these respondents were environmental protection officials, four were agricultural officials, five were pesticide registration officials, two were representatives of the industry, five were representatives of the farming sector, 2 were from NGO's and 1 was a so-called 'other'.

reduction of pesticides in the European Union (strategy IV). Improvements in application technology and inspection of application were ranked at the second and third place there.

It should be noted that a levy on pesticides was one of the nine instruments that had to be judged by the respondents on its usefulness to restrict the use of highly hazardous pesticides (the first strategy)[8]. With respect to the criterion of effectiveness the levy was ranked at the sixth place, with respect to the criterion of acceptability it was ranked eight, with respect to enforceability it was ranked third.

Both the results of the questionnaire and of Table 3.2 should not be regarded as conclusive, because the quality of the outcomes cannot be guaranteed. Nevertheless, it is difficult to ignore the signal which arouse from both analyses. When compared to other policy instruments there seems to be a preference to use arrangements and regulative instruments (especially speeding up the review of Council Directive 91/414/EEC) to reduce pesticide use in agriculture rather than market-based instruments, such as a levy on pesticides. It is interesting to mention in this respect that one of the final recommendations of the second workshop on a framework for the sustainable use of plant protection product in the European Union was that '*the workshop did not find consensus on the use of levies, and that they need to be further investigated*'.

3.3 Usefulness of market-based instruments to reduce the use of pesticides

From Table 3.2 it can be seen that Oskam et al. (1997) ranked two instruments in the group of market-based instruments with '++' (good), five with '+' (moderate), and two with '-' (low). In analysing the usefulness of these instruments to reduce the use of pesticides, it is interesting to present and discuss the detailed judgements of Oskam et al. (1997) (see Table 3.3 on the next page).

On the basis of their scores on the six criteria, the 10 market-based instruments in Table 3.3 have been arranged into four groups:

1. Oskam et al. (1997) considered a *uniform high VAT on plant protection products* (ppps) as the most useful market-based instrument for reducing the use of pesticides in the agricultural sector. Although the effectiveness of this instrument is regarded moderate ('+'), its efficiency, acceptability, enforceability and (no) disturbance of income and properties is judged as (very) good.
2. The second group of market-based instruments in Table 3.3 consists of *a levy on ppps, adjusting some of the agri-environmental measures of the CAP* and *using premiums to prevent environmental hazard*. Within this group, Oskam et al. (1997) considered a levy on ppps, whereby the revenues are used for pesticide reducing programs, more useful than the other three instruments. The difference with a levy on

[8] A levy on pesticides did not have to be judged for the last strategy.

ppps where the revenues are directly reimbursed to the farmers is, however, small. Also premiums to prevent environmental hazard is regarded as quite useful. Should one of the criteria have been budget neutrality at the level of the European Union, this instrument would have been probably ranked lower.

Table 3.3 Detailed evaluation of 10 market-based instruments to reduce pesticide use.

	effectiveness	efficiency	acceptability	enforceability	homogeneity	disturbance (income, property)	general
uniform high VAT on ppps	+	+++	++	+++	++	+++	++
levy on ppps (to raise budget for programs)	++	++	+/-	+++	+	+	++
levy on ppps (with reimbursement to farmers)	++	+	+	+++	0	++	+
adjusting agri-environmental measures of the CAP reform	+	+	++	+/-	+	++	+
premiums (to prevent environmental hazard)	++	+	++	+	+	+	+
differentiated VAT on ppps	++	+++	+	?	-	++	+
levy on ppps (to be included in general budget)	++	++	-	+++	+	-	+
reduced use of ppps as a condition for income support	++	-	+	+/-	+	0	0
marketable permits	++	--	-	+/-	-	++	-
insurance on yield risk	-	--	n.r.	n.r.	-	n.r.	-

Source: Oskam et al. (1997)

3. The third group of market instruments in Table 3.3 consist of a *differentiated VAT on ppps* and *a levy on ppps with the aim to use the revenues for the general budget*. Compared to the above-mentioned instruments, these market-based instruments are sub-optimal due to their low acceptability (levy) and low homogeneity (differentiated VAT on ppps).

4. The latter group of market-based instruments in Table 3.3 consists of three instruments: *reduced use of ppps as a condition for income support*, *marketable permits* and *insurance on yield risk*. These instruments score (very) low with respect to the criterion of efficiency. Also on other criteria these instruments are inferior to the above-mentioned instruments.

Summarising the above, it can be concluded that three of the market-based instruments in Table 3.3 may be considered useful for reducing the use of pesticides in agriculture, two of them being a levy on pesticides:

- a uniform high VAT on pesticides;
- a levy on pesticides to raise budget for programs;
- a levy on pesticides with reimbursement to farmers.

Probably, the major reason behind the usefulness of a levy on pesticides relates to the fact that a levy introduces an automatic incentive for the farmer to use the pesticides more efficiently, to use other (less harmful) pesticides or to use biological alternatives of the pesticides. As a beneficial side-effect, levies might stimulate a more rapid innovation in industry towards less harmful pesticides. Another major benefit of a levy on pesticides relates to the sovereignty of the farmer to adjust his behaviour in his own best way: i.e., optimal with respect to the economy of the farm. This characteristic of a levy warrants a cost-efficient reduction of pesticides in the agricultural sector[9]. A point of concern could be the reimbursement of the revenues of the levy. There are various possibilities (see, chapter 6). If the revenues are reimbursed to the sector, the acceptability of the instrument will certainly increase. Moreover, an adequate reimbursement could further reduce the use of pesticides, for example, by subsidising specific training programs on integrated pest management.

The use of a levy fits within the generally accepted principle that *polluters should pay* for the damage they cause to the environment. In this case, policy instruments for reducing the use of pesticides should be set at the level of the farm, rather than at the level of industry, such as Council Directive 91/414/EEC. In fact, farmers play a central role in reducing the use of harmful pesticides. Controlling the usage and dosage of pesticides at the farm is, however, unworkable. By using a levy, such an intensive controlling system would become redundant.

3.4 A levy on pesticides: the ideal case

Given the above advantages of a levy on pesticides, it is interesting to define the ideal case. In other words, how would the ideal European Union wide levy on pesticides looks like? Below, five conditions have been set on which such a levy should score '+++' (using the terminology of Oskam et al. 1997) in order to be ideal.

9 Moreover, levies are especially useful in case of non-point pollution and when environmental impacts are widespread (see RSPB, 1998). This is certainly the case with pesticides. Levies are less appropriate when there are hotspots (point pollution) or where localized activities have a disproportionate impact.

1. The ideal levy discriminates effectively among the various pesticides
Firstly, the ideal levy should discriminate effectively among the various pesticide used at the farm. In other words, the levy should be proportional to the damage pesticides cause to the environment. Pesticides which are most harmful to the environment should be levied the most.

2. The ideal levy is set at the correct rate
Secondly, the ideal levy should be set at the correct rate. From a theoretical point of view, this means that the amount charged to the farmers is equivalent to the marginal external costs of the pesticides. If set at this rate the marginal social costs of using pesticides will match the corresponding social marginal benefits. Since it is very difficult, if not impossible, to determine the exact marginal external costs of pesticides, usually the 'correct' rate of the levy is determined by taking into account the efficiency of using the charged products (i.e., the efficiency of pesticide use) and the number and quality of environmental-friendly alternatives. The ideal levy encourages farmers to change their behaviour in a more environmental-friendly way.

3. The ideal levy has an efficient collection and effective reimbursement system
Thirdly, the ideal levy should have an efficient collection and effective reimbursement system. With respect to the former, the way the levies are collected is important. The ideal levy is collected with a minimum of administration costs. With respect to the latter, the way the revenues are returned to those involved is important. The revenues of the ideal levy should be reimbursed in such a way that:
1. a maximum acceptability is achieved, both at the political level and at the level of the farmers, and
2. the use of the most harmful pesticides is reduced at the farm.

4. The ideal levy is fraud-proof
Fourth, the ideal levy should be collected with a minimum of fraud practices. Therefore, the levy should be set at the level of the European Union to counteract possible fraud at the inter-borders. Moreover, it should be feasible and maintainable from an administrative point of view with little possibilities for fraud (see also chapter 6).

5. The levy implies a permanent incentive to farmers
Finally, the levy should imply a permanent incentive to the farmers: either to use pesticides more efficiently at the farm or to change to less-harmful pesticides. This means that a market-based oriented pesticide policy of the European Union has a long-term environmental perspective rather than a short-term political perspective.

Unfortunately, the ideal levy on pesticides cannot be established yet. Two main obstacles are:

1. the exact environmental effects of many pesticides are not known, and, when they are known, the various types of environmental damages are difficult to summate into one single target. Hence, it is not possible to discriminate perfectly among the various pesticides.
2. the optimal rate of the levy cannot be determined. On the one hand, this is because the environmental effects of pesticides cannot be monetarised, on the other hand, this is because relevant information on the efficiency of pesticide use at the farms and the number and quality of environmental-friendly alternatives is still limited.

These obstacles relate to the first two conditions stated above. Together they prevent the occurrence of an ideal European Union wide levy on pesticides. The remaining three conditions stated above pose less major obstacles. Hence, it seems possible to create both an efficient (fraud-protection) collection and an effective reimbursement system (see chapter 6). By imposing a levy on pesticides to all the Member States of the European Union possible inter-border effects are diminished. Finally, the Commission can decide to design a market-based pesticide policy for the long-term.

3.5 Using levies to reduce pesticide use in agriculture: a review

Having analysed the potential benefits of a levy on pesticides, it is interesting to look at practical experiences in the Member States of the European Union with regards to a levy on pesticides. Unfortunately, this experience is limited (see Oskam et .al. 1997; Vos, 1998; RSPB, 1998). At the moment, only four countries use such a policy instrument: United Kingdom, Finland, Sweden and Denmark. Of these countries, the first two use a levy purely with the aim to finance their pesticides registration system, the latter two countries use a levy with an aim to reduce the use of harmful pesticides in agriculture.

United Kingdom and Finland

In the United Kingdom, levies are used to finance the pesticides registration system of the country. Firstly, there is a target fee for the registration of a new active ingredient (this fee can be up to € 5,000). Secondly, there is a general fee for companies to pay towards the costs of post-approval monitoring of pesticides. The latter amount is a percentage of the UK sales of pesticide registration holders.

In Finland, there is a 2.5% registration charge on the net selling price of pesticides. The revenues of this levy are used to finance the costs of maintaining the pesticides register and to offset the costs of handling registration applications. Besides this levy there is also a target fee of about € 1,000 for the registration of new active ingredients.

Sweden and Denmark

Since 1995 Sweden has a tax on active ingredients, entailing a price increase of about € 2.2 per kg. Although there is no formal link between the revenues of this tax and governmental costs in the field of pesticides, most of the revenues are used to finance research and extension work in agriculture and forestry, including mandatory training courses, regional plant protection centres which promote integrated crop management, advisory services, and voluntary testing of spraying equipment. The Swedish environmental tax on active ingredients has been effective insofar as the volume of pesticides in agriculture in Sweden has been reduced by 35% in the period 1981/1985 to 1995. Yet, it should be acknowledged that this reduction is mainly the *indirect* effect of the tax, through an efficient financing of advisory services, research and development, etceteras. It is difficult to isolate the *direct* effect of the tax: i.e., the reduction of the use of pesticides at the farm due to a price increase of € 2.2 per kg active ingredient.

In the nearby future the charge base of the Swedish environmental tax will be changed towards the retail price of pesticides (see Vos, 1998). Such a change is advised by the Swedish National Board of Agriculture the main argument being that pesticides with a smaller content of active ingredients, at the moment, are less affected by the tax but do not necessarily have a smaller environmental impact. By charging the pesticides on the basis of their retail price such 'imperfections' could be reduced (the issue on the charge basis of the levy will be elaborated on in chapter 6).

Since 1996 Denmark has a differentiated levy on pesticides. The levy differs to the type of pesticides: insecticides are levied by 37% of the retail price, whereas herbicides, fungicides and growth regulators are levied by 15%. These percentages are derived from an overall levy of 25% on all pesticides sold by retailers. The motive behind a higher levy on insecticides was based on information of a considerable over-use of this type of pesticide in Denmark. It is estimated that the differentiated levy on pesticides will reduce the use of pesticides in agriculture in Denmark by 5 to 10% (see Jorgenson and Secher, 1996). The revenues of the levy are estimated at € 28 million per year. The major part of this amount is transferred back to the agricultural sector by reducing the tax on agricultural land. The remaining revenues of the levy will be kept in reserve to be returned later.

Lessons to be learned

On the basis of the above review, three lessons can be learned:

1. From the experiences in Sweden it follows that the indirect effects of a relative small tax on pesticides could be quite large by using the revenues of the tax effectively.
2. From the experiences in Denmark it follows that a differentiated levy on pesticides is possible and useful if some pesticides need to be reduced more than others.
3. From the experiences in Denmark and Sweden it follows that a levy on pesticides which is charged on the retail price of pesticides rather than on the active ingredients has different effects. As mentioned above, this issue will be elaborated on in chapter 6 where a European Union wide regulatory framework for levies on pesticides will be discussed.

3.6 Conclusions

In section 1.2 six research questions have been formulated. On the basis of the information in the previous sections, the first three of them can be answered. These three questions are:

1. In what respect is the experience presently available in the Member States on the use of pesticides useful for developing an EU wide regulatory framework for levies on pesticides?
2. What would constitute the ideal EU wide levy on pesticides?
3. Are there potential bottlenecks, if any, which could hinder the introduction of such a levy on pesticides?

With respect to the first research question it can be concluded that there is little relevant experience available in the Member States of the European Union which is useful for the design of an EU wide regulatory framework for levies on pesticides. In fact, at the moment only in Sweden and Denmark a levy on pesticides is used in a way to influence the farmer's behaviour.

Whereas the main economic and environmental effects of the levies in Denmark and Sweden are difficult to isolate, the levy-systems used in these two countries encompass interesting lessons which could be beneficial for an EU wide regulatory framework for levies on pesticides. Note that these lessons refer mainly to the organisational side of such a framework. From Sweden and Denmark there is relevant experience available on ways to reimburse the levy, on ways to charge the levy (retail price or active ingredients), on ways to differentiate the levy and on ways to collect the levy.

The ideal levy on pesticides is defined in section 3.4. Five conditions were formulated: i.e. the ideal levy discriminates effectively among the various pesticides, is set at the correct rate, has an efficient collection and effective reimbursement system, is fraud-proof and provides a permanent incentive to the farmers.

Of these conditions, the first two are confronted with major obstacles: i.e., there is little knowledge on the effects of the various pesticides to the environment, and it is difficult to set the levy at the correct rate. Therefore, it can be concluded that from an organisational point of view there seem to be no major obstacles for a European Union wide levy on pesticides. Concerning the contents of the levy, however, there are important complications.

Next to the above conclusions, this chapter has shown that a levy on pesticides is judged useful in itself (see Table 3.3). Compared to other policy instruments, such as arrangements and regulations, however, market-based instruments are not rated very high to reduce the use of pesticides in agriculture (see Table 3.2). In fact, speeding up the review of

Council Directive 91/414/EEC is generally regarded by scientists and policy-makers as the most effective policy instrument at the moment.

4 Analysing the effects of a levy on pesticides

4.1 Introduction

Up to now the study has focused on the pro's and contra's of a levy on pesticides, when compared to other policy instruments (e.g. regulations, arrangements) as well as market-based instruments (e.g. uniform VAT). The general conclusion of this review was that a levy on pesticides in itself can be judged as useful and potentially effective. Compared to other policy instruments, however, a levy is not regarded the most effective to reduce the use of pesticides in the European Union. Speeding up the review of Council Directive 91/414/EEC is generally preferred by scientists and policy makers.

Nevertheless, the potential effectiveness of an EU wide levy on pesticides warrants an evaluation of its main economic and environmental effects. Such an evaluation will be presented in chapter 5. Before that, the basis of this evaluation - i.e. the economic model used - needs to be described. This forms the contents of this chapter. Section 4.2 starts by presenting a classification of the pesticides with respect to their negative effects to the aquatic environment. This classification will be used in designing an effective levy framework for the various pesticide chains. Section 4.3 deals with the theoretical framework that lies behind the model used to analyse the economic effects of a levy on pesticides. In section 4.4 the model itself is presented. Compared to the ideal model, simplifications had to be made due to limitations in the availability of data. By using the model several interesting aspects can be estimated, such as the impact of the levy on the use of pesticides, on the costs of pesticides and on the farmer's income. Section 4.5 reviews the state of the art with respect to the price elasticity's of demand of pesticides. Finally, section 4.6 presents the main conclusions.

4.2 Classifying pesticides with regards to their effects to the aquatic environment

An adequate risk assessment of pesticides is usually divided into four steps: (I) hazard identification, (II) dose-response assessment (together these two steps are also known as an effect-assessment), (III) exposure assessment and (IV) risk characterisation.

In this study the environmental effects of the pesticides will only be estimated on the basis of the first step mentioned above: the hazard identification. This means that it is only considered whether exposure to the substance *could* cause adverse effects to the environment. Such an approximation is chosen because an assessment of concentrations of the pesticides in the environment is not possible within the context of this study. Furthermore, as a worst-case approach it is assumed that the pesticides do reach the environment after application and that, as a result, the individual properties of the substances will be decisive for the effects to the environment.

The environmental effects of pesticides can be based upon the criteria described in Annex VI of Council Directive 93/21/EEC (general classification and labelling requirements for dangerous substances and preparations) and the criteria defined in the Uniform Principles of Council Directive 91/414/EEC. By using these two Directives, this hazard identification follows the recommendations of Reus et al. (1994) who mentioned both Directives as suitable documents for defining the criteria and standards of impacts to the aquatic and non-aquatic environment.

As a first step in the classification of the pesticides it is proposed to classify the various pesticides on the basis of their negative effects to the aquatic environment. It is acknowledged that this option is only one of the options available, for example, one could also classify the pesticides on the basis of their negative effects to the non-aquatic environment or to their health risks. However, following Reus et al. (1994) a major part of the environmental impact of pesticides is directed to a contamination of the groundwater and surface water. By focusing on the effects of the pesticides on the aquatic environment difficulties could result for some Member States, such as Spain, where the groundwater is deep under the surface and other environmental impacts are more important.

Whereas the evaluation according to the Uniform Principles of Council Directive 91/414/EEC is based on the application of toxicity-exposure ratio's, i.e., a combination of substance-intrinsic properties and concentrations expected to occur in the environment, the general classification and labelling requirements of Council Directive 93/21/EEC only focus on toxicity data for substances. Therefore, in this study the classification for the aquatic environment according to Council Directive 93/21/EEC is considered a suitable approximation.

Following the criteria for classification defined in Council Directive 93/21/EEC, substances shall be classified as dangerous for the environment and assigned the symbol 'N' and the appropriate indication of danger, and assigned risk phrased in accordance with the following criteria:

- *Very toxic to aquatic organisms (R50), and may cause long-term adverse effects in the aquatic environment (R53).* Acute toxicity:

96 hr LC_{50} (for fish)	$\leq$ 1 mg/l, or
48 hr EC_{50} (for Daphnia)	$\leq$ 1 mg/l, or
72 hr IC_{50} (for algae)	$\leq$ 1 mg/l,

and the substance is not readily degradable, or the log Pow (log octanol/water partition coefficient) $\geq$ 3.0 (unless the experimentally determined BCF $\leq$ 100).

- *Very toxic to aquatic organisms (R50).* Acute toxicity:

96 hr LC_{50} (for fish)	$\leq$ 1 mg/l, or

48 hr EC_{50} (for Daphnia)	≤ 1 mg/l, or
72 hr IC_{50} (for algae)	≤ 1 mg/l.

- *Toxic to aquatic organisms (R51), and may cause long-term adverse effects in the aquatic environment (R53).* Acute toxicity:

96 hr LC_{50} (for fish)	1 mg/l < LC_{50} ≤ 10 mg/l, or
48 hr EC_{50} (for Daphnia)	1 mg/l < EC_{50} ≤ 10 mg/l, or
72 hr IC_{50} (for algae)	1 mg/l < IC_{50} ≤ 10 mg/l

and the substance is not readily degradable or the log Pow ≥ 3.0 (unless the experimentally determined BCF ≤ 100).

Following the criteria for classification defined in Council Directive 93/21/EEC, substances shall be classified as dangerous for the environment in accordance with the criteria set out below. Risk phrases shall also be assigned in accordance with the following criteria:

- *Harmful to aquatic organisms (R52), and may cause long-term adverse effects in the aquatic environment (R53*). Acute toxicity:

96 hr LC_{50} (for fish)	10 mg/l < LC_{50} ≤ 100 mg/l, or
48 hr EC_{50} (for Daphnia)	10 mg/l < EC_{50} ≤ 100 mg/l, or
72 hr IC_{50} (for algae)	10 mg/l < IC_{50} ≤ 100 mg/l,

and the substance is not readily degradable.

Substances not falling under the criteria listed above, which on the basis of the available evidence concerning their toxicity may nevertheless present a danger to aquatic ecosystems:

- *Harmful to aquatic substances* (R52).

Finally, substances not falling under the criteria listed above in this chapter, but which, on the basis of the available evidence concerning their persistence, potential to accumulate, and predicted or observed environmental fate and behaviour may nevertheless present a long-term and/or delayed danger to the structure and/or functioning of aquatic ecosystems. For example, poorly water-soluble substances, i.e. substances with a solubility of less than 1 mg/l will be covered by this criterion if they are not readily degradable; and the log Pow ≥ 3.0 (unless the experimentally determined BCF ≤ 100):

- *May cause long-term adverse effects in the aquatic environment* (R53).

On the basis of the above classification, pesticides can be divided into seven classes, ranging from pesticides which are very toxic to the aquatic environment and may cause long-term adverse effects, to pesticides which are only harmful to aquatic organisms. In the box (on the next page) the precise classification is presented. This classification will be used in the various pesticide chains (see chapter 5), and may be used as a basis for a charge base system of an EU wide levy on pesticides (see chapter 6). If the latter is the case, a pesticide which is regarded very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment should be levied more than a pesticide which may cause long-term adverse effects in the aquatic environment (see also section 3.4).

Classifying the pesticides according to their potential risk to the aquatic environment

I.	Very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment;
II.	Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment;
III.	Harmful to aquatic organisms and may cause long-term adverse effects in the aquatic environment;
IV.	May cause long-term adverse effects in the aquatic environment;
V.	Very toxic to aquatic organisms;
VI.	Toxic to aquatic organisms;
VII.	Harmful to aquatic organisms.

4.3 Analysing the effects of a levy: theoretical framework

In the literature, various economic models exist to analyse the effects of (pesticide) levies on the behaviour of households and firms (farmers). With respect to pesticides different approaches have been followed, varying from simply rules of thumb (e.g. Oskam et al., 1997) to sophisticated dynamic and behavioural models (e.g. Oskam et al., 1992). The sophisticated models are either neo-classical or based on linear-programming. In this study, the neo-classical approach has been adopted as it provides an adequate tool for analysing the farmer's behaviour.

Key elements in the neo-classical approach are the production function and the farmer's aim to maximise his or her income. This income is defined as being equal to the difference between revenues and costs. Revenues are calculated from the output price of a crop (assumed to be exogenous) and the quantity of crops sold. Output itself depends on the quantity and quality of various input factors (see below). Cost depends on the amount of input factors, as well as on factor prices.

As an illustration of the foregoing, it is assumed that a farmer has four factors of production: labour (L), capital (K), pesticide A and pesticide B. Then, the following definitions can be derived:

(1)	$\Pi =$	$R - C$	farmer's income
(2)	$R =$	$y \cdot p_y$	revenues
(3)	$C =$	$K \cdot p_K + L \cdot p_L + A \cdot p_A + B \cdot p_B$	costs

where:

Π	farmer's income
R	revenues
C	costs
y	amount of crops
p_Y	price of crops (exogenous)
K	amount of capital used in production
p_K	price of capital
L	amount of labour used in production
p_L	price of labour
A, B	amount of pesticides A and B used in production
p_A, p_B	price of pesticides A and B

Usually, labour and capital are viewed as the 'normal' production factors. For a farmer, however, pesticides can be seen as a production factor too, since without these plant protection products, substantial less production of crops is possible. The total production of crops is positively correlated with the use of each production factor. The mathematical relationship between production and production factors is called the production function. In (4) this function is presented:

(4) $y = f(K, L, A, B)$

$f'_i > 0$, $i = K, L, A, B$

$f''_i < 0$, $i \in K, L, A, B$

$f'_{i,j} > 0$, $i, j \in K, L, A, B$, $i \neq j$

where:

y	amount of crop
K	amount of capital used in production
L	amount of labour used in production
A, B	amount of pesticides A, respectively B. used in production

f'_i, f''_i first, respectively second derivative with respect to argument I

From the foregoing, it follows that the representative farmer maximises his or her income by:

(5)	choosing L, K, A, B:	$\Pi = R - C$
	subject to	(2), (3), (4)
	given	p_Y, p_K, p_L, p_A, p_B

Solving the mathematical problem (5) gives the following general results:

(6)	$x_i =$	$x_i(p_K, p_L, p_A, p_B, p_Y)$	use of production factor i
	where	$x'_{i,i} < 0$	derivative of x_i with respect to the price of factor i

The quantity of produced crops follows from substituting the results of (6) into equation (4). Furthermore, it can be proved that, taking log differences:

(7) $\Delta ln\, y \approx \quad \Sigma_i\, w_i \cdot \Delta ln\, x_i$

where:

$\Delta ln\, y$ relative change of production of crops

$\Delta ln\, x_i$ relative change of production factor i (i= L, K, A., B)

w_i share of production factor i (i= L, K, A., B) in total costs ($\Sigma_i\, w_i = 1$)

Hence, under general assumptions[10], it appears that an introduction of a levy on pesticides will lead to an increase in costs, a reduction of the use of the levied pesticide (accompanied by an increase of the use of other pesticides[11], and an increase of the use of the other factors of production), a reduction of production of crops, and therefore of revenues and a reduction of the farmer's income

4.4 Introducing a simplified economic model

Fully implementing the neo-classical approach as constituted by equations (7) and (4) necessitates the use of data which are not available yet. Thus, a simplified version of the economic model had to be designed, focusing on the main purposes of the study. In this respect, the following assumptions had to be made: the prices of capital and labour are

[10] For example, if the production function (4) is a CES-function

[11] Of course, when both pesticides are levied, the use of both will decrease

constant[12], and the production function in (4) is a so-called nested CES-function. More specifically, the following production function is assumed:

(4') $y = \mathrm{CES}\{f(K, L), g(A, B)\}$ with elasticity of substitution σ

where:

$f(K, L)$ function in which capital K and labour L are combined, having the same properties as (4)

$g(A, B)$ function in which pesticides A and B are combined.

In the simplified economic model it will be assumed that g is of the Leontief-type, that is:

(8) $g(A,B) = \min\{\alpha^{-1} \cdot A, \beta^{-1} \cdot B\}$

Assumption (8) follows from the observation, that with technology given, farmers tend to use pesticides in equal proportions.

The above assumptions imply that factor demand equations can be written as:

(9a) $A = \text{constant} \cdot (p_A/p_Y)^{-\sigma}$

(9b) $B = \text{constant} \cdot (p_B/p_Y)^{-\sigma}$

Finally, taking the log differences, and assuming the price of crops to be constant:

(9a') $\Delta ln\ A = -\sigma \cdot \Delta ln\ p_A$

(9b') $\Delta ln\ B = -\sigma \cdot \Delta ln\ p_B$

The latter equations allows one to determine the impact of price changes on the use of pesticides. In analysing the impact of changes in the use of pesticides on the production level, equation (7) can be used; the parameters w_i in this equation can be determined empirically. Hence, for each pesticide there is only one elasticity of substitution determining the impact of levies on the use of pesticides, and therefore on the level of crop production. Since prices of output as well as factors of production are given, this substitution elasticity also determines the impact of the levies on the farmers' income.

Generally, the values of the relevant substitution elasticity's are not known, due to a lack of data. However, from literature research and expert knowledge, plausible values can be derived. Therefore, in using the simplified economic model, scenarios can be developed, indicating lower and upper bands.

[12] Since only the introduction of levies on pesticides is subject of study, this seems a reasonable assumption

4.5 A review of price elasticity's of demand of pesticides

The price elasticity of demand of pesticide used in agriculture is an important variable in designing an EU wide regulatory framework for levies on pesticides. For example, if pesticide use is almost indifferent to price increases of pesticides, perhaps due to a high efficiency of pesticide use (see chapter 2), the introduced levy will generate substantial revenues whereas the direct beneficial environmental effects of the levy will be small. Table 4.1 presents an overview of studies that have estimated price elasticity's of demand of pesticides, using different models, such-as regression analysis, linear programming and threshold models. The studies are ordered by the country upon which the study is based.

Table 4.1 Overview of research on the price elasticity's of demand of pesticides.

Study	*country*	*elasticity*	*demand of*	*remarks*
1. *Oskam (1997)*	EU	-0.2 to -0.5	pesticides	general overview of other studies
2. *Elhorst (1990)*	Netherlands	-0.3	non-factor inputs	short term; arable farming, based on data 1980-1986
3. *DHV and LUW (1991)*	Netherlands	-0.2 to -0.3	pesticides	short term: -0.2 for arable farming; -0.3 for horticulture
4. *Oskam (1992)*	Netherlands	-0.1 to -0.5	pesticides	medium term: -0.1 for mixed farms (potatoes, unions); -0.5 for specialised farms
5. *Oude Lansink and Peerlings (1995)*	Netherlands	-0.5 to -0.7	pesticides	based on data 1970-1992; -0.7 is inclusive the CAP reform
6. *Russell (1995)*	UK	-1.1	pesticides in cereals	based on 26 cereals producers; period 1989-1993
7. *Falconer (1997)*	UK	-0.3	pesticides	using a linear programming model
8. *Ecotec (1997)*	UK	-0.5 to -0.7	herbicides	long term; only for herbicides used for cereal grass weed
9. *Dubgaard (1987)*	Denmark	-0.3	pesticides	using a threshold model
10. *Dubgaard (1991)*	Denmark	-0.7	herbicides	long term; period 1971-1985
11. *Dubgaard (1991)*	Denmark	-0.8	fungicides and insecticides	long term; period 1971-1985
12. *Schulze (1983)*	Germany	-0.5	fungicides	using a linear programming model
13. *Johnsson (1991)*	Sweden	-0.3 to -0.4	pesticides	based on filed experiments; -0.3 for insecticides, -0.4 for fungicides
14. *Gren (1994)*	Sweden	-0.4 to -0.9	pesticides	econometric model; -0.4 fungicides, -0.5 insecticides and -0.9 herbicides
15. *SEPA (1997)*	Sweden	--0.2 to -0.4	pesticides	general overview

Source: EIM

From Table 4.1 it can be seen that the price elasticity of demand for pesticides is higher, the more it is specific. The reason behind this (familiar) phenomenon lies in the number of substitutes available to the farmer to adjust his behaviour. By putting the same levy on all pesticides, substitution of pesticides by other pesticides is more difficult to realise.

Table 4.1 shows an 'overall' price elasticity of demand for pesticides between - 0.2 and - 0.5 (based on the studies no. 2, 3, 4, 5, 7, 9 and confirmed by study no.1 and 15). Compared to the above price elasticity, the 'overall' price elasticity of demand for herbicides, fungicides and insecticides is higher. With respect to herbicides the price elasticity seem to lie between - 0.7 to - 0.9 (based on studies no. 10 and 14), for fungicides the price elasticity seem to lie between - 0.4 to - 0.8 (based on studies no. 11, 12, 13, 14), for insecticides the price elasticity seem to lie between - 0.3 to - 0.8 (based on studies no. 11, 13 and 14). Finally, the price elasticity of demand for pesticide used for a special crop, such as pesticides in cereals seem to be the highest. From Table 4.1 the price elasticity for such specialised pesticides seem to lie between - 0.5 and -1.1 (based on studies no. 6 and 8).

Finally, the information in Table 4.1 enables one to conclude that the long-term price elasticity of demand for pesticides is higher than the short-term elasticity. This is a well-known phenomenon in the economic literature. In the long-term, demand may be more likely to be responsive to price change for several reasons: cropping practices are more flexible, capital investment and changes in cropping patterns are possible, etceteras (see RSPB, 1998).

4.6 Conclusions

This chapter has shown that pesticides can be classified according to their negative effects to the aquatic environment is possible. Seven classes have been distinguished. The most hazardous pesticides are those pesticides which are very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment (I). The less hazardous pesticides are those pesticides which are harmful to aquatic organisms (VII). In determining the potential effectiveness of a levy on pesticides this classification will be used in the next chapter. As mentioned before it may even be used as a basis for a charge base system of an EU wide levy on pesticides.

Due to data limitations the economic model which will be used in chapter 5 is simple in nature. The theoretical background of the model is neo-classical oriented. This means that farmers are assumed to behave rationally and aim at maximising their incomes. Moreover, the use of pesticides is regarded as one of the key production factors. Under general assumptions, it appears that the introduction of a levy on pesticides will lead to an increase in variable costs, a reduction of the use of the levied pesticide, a reduction of the production of crops and therefore of revenues, and a reduction of the farmer's income.

The review of studies that have estimated price elasticity's of demand for pesticide used in agriculture shows an 'overall' price elasticity of demand for pesticides between - 0.2 and - 0.5. This would mean that a price increase of, say 20%, would result in a reduction of the use of pesticides in the European Union between 4% and 10%. The price elasticity of demand for herbicides lies between - 0.7 to - 0.9, for fungicides between - 0.4 to - 0.8, and for insecticides between - 0.3 to - 0.8. This information will be used in chapter 5 where for each pesticide chain the most appropriate price elasticity will be substantiated.

5 Evaluating the effects of a levy on pesticides

5.1 Selecting the pesticide chains

In order to evaluate the potential effects of EU wide levy on pesticides satisfactory, the study aimed at analysing at least 20 pesticide chains in the European Union. Such a number was regarded necessary to satisfy the various demands on the choice of pesticide chains, for example, those which emerged from chapter 2. In general, the following criteria are important in selecting the pesticide chains:

- type of pesticides and crops involved;
- intensity and efficiency of pesticide use;
- available alternative plant protection devices;
- environmental conditions (soil properties, climate, temperature).

Ideally, the pesticide chains selected should encompass a representative part of the use of pesticides in agriculture in the European Union. Hence, pesticide chains should be selected in situations with a low intensity of pesticide use and a high intensity, with a low efficiency and a high efficiency, with maritime and subtropical crops, with many and few available alternatives, etceteras. On the basis of the chosen set of pesticide chains it should be possible to provide reliable statements on the effectiveness of an EU wide levy on pesticides.

During the study it became clear that the above aim of 20 pesticide chains was too ambitious. The main reason formed a lack of information in the southern Member States, such as Italy, Spain and France (the major users of pesticides in the European Union, see Table 2.2). Even though several calls have been made with pesticide experts in these countries, it was not possible for them (within the conditions of this study) to obtain the necessary information to evaluate the effects of an EU wide levy (see section 5.2 for the information needs of pesticide chains). Moreover, it became clear that it was not reasonable to be too strict on the other criteria mentioned above.

Table 5.1 presents the ten pesticide chains which have been evaluated in this study. Taken together, these chains comprise three different types of pesticides (herbicides, fungicides and insecticides), seven different crops (both arable and horticulture)[13] and four different regions. To some extent, the selected pesticide chains are biased towards the Netherlands. This is due to the fact that relevant data were relatively easy to get there and quite comprehensive.

[13] Although using herbicides to counteract weeds at public pavements and roads does not fit within the scope of this study (i.e., pesticides used in agriculture) this pesticide chain has been included and evaluated on request of DG XI.

Table 5.1 Overview of selected pesticide chains

Type of pesticide used	Disease	Cultivated crop	Region or country
1. Fungicides	mildew	lettuce	England/Wales
2. Fungicides	mildew	green peppers	Almeria (Spain)
3. Insecticides	insects	cucumbers	the Netherlands
4. Insecticides	insects	cucumbers	England/Wales
5. Fungicides	phytopthora	potatoes	Sweden
6. Fungicides	phytopthora	potatoes	the Netherlands
7. Herbicides	weeds	corn	the Netherlands
8. Herbicides	weeds	winter barley	England/Wales
9. Fungicides	rust, mildew	winter wheat	Sweden
10. Herbicides	weeds	public pavements, roads	the Netherlands

Source: EIM

Due to the available information, the majority of the crops involved in the pesticide chains analysed, are cultivated in continental and maritime climate conditions: i.e., potatoes, cucumbers, corn, winter barley and winter wheat. Unfortunately, other interesting crops, such as grapes, citrus fruits and olives had to be excluded from the analysis. With respect to the types of pesticides, the chains encompass most of the pesticide used in agriculture. Brouwer et al. (1994), for example, have estimated that the selected types of pesticides cover about 90% off all pesticide sales in the European Union.

In the remaining sections of this chapter first the information needs of pesticide chains are described. Then, the general assumptions are discussed which underlie the evaluations. Section 5.4 is devoted to the results of the ten pesticide chains. Finally, the key conclusions of the pesticide chains are drawn.

5.2 Information needs of pesticide chains

To evaluate the effects of an EU wide levy on pesticides satisfactory, for each pesticide chain the following information had to be collected:

1. *identification of the pesticide chain (crops, pesticides and regions involved)*: i.e., which crop is involved, what is the number of acres involved in the region, what is the number of farms involved, which types of farms are involved (mixed, specialised, mean size, etc.), which pesticides are the most crucial, which pesticides are the most used, what crop diseases are involved, what is the crop's dependency on pesticides, what tendency is there in the usage of the pesticides, are the pesticide used substitutes or are they complementary to each other?

2. *amount and costs of the pesticide used:* i.e., what is the amount (in active ingredients) of the pesticide used, per acre and per year, what are the costs to the farmer in using the pesticides calculated as percentage of the output and of the variable costs.
3. *price of the pesticides:* i.e., what is the retail price of the pesticide used and what is the price of the pesticides calculated per kg active ingredient.
4. *environmental hazards of the pesticides:* i.e., what are the environmental hazards involved of the pesticide used, what is the relevant classification (see section 4.2)
5. *potential alternatives:* i.e., what alternatives are available for the farmer.

As an example of the information which pesticide experts in the Netherlands, UK, Sweden and Spain gathered, the *information sheet* of the chain *fungicides in potatoes in the Netherlands* is presented below. In fact, this information has been used in order to execute the economic model (see also Annex II).

Fungicides in potatoes in the Netherlands

Identification of the pesticide chain

- *Culture*: Potatoes in the Netherlands;
- *Type of pesticide*: fungicide (protection against *Phytophthora infestans)*
- *Most important chemical means* (together 90%);
  Triphenyltinacetate (Inhibition of important physiological processes, causing death of fungi)
  Mancozeb (blockade of metabolism in fungi by inhibiting enzymes in citric acid cycle)
  Maneb (blockade of metabolism in fungi by inhibiting certain enzymes in citric acid cycle)
  Fluazinam (inhibition of cell division in fungi)
- *Type of farms involved:* average size: 42 hectare (LEI-DLO, 1994)

Volume, prices, costs and environmental risks of the pesticide used

- *Volume in active ingredients, prices per kg active ingredients, environmental risks in 7 categories (see section 4.2)*

Triphenyltinacetate:	126 ton /year	€ 40	category I
Mancozeb:	511 ton /year	€ 7	category VI
Maneb:	557 ton /year	€ 5	category V
Fluazinam:	115 ton /year	€ 90	category V

- *Costs of the pesticides:* less than 6% of the total yield per hectare.

Potential ppps alternatives

- *Preventive and biological counteraction:* use of resistant crops (approximately 50% of the farmers involved use these crops), use of untainted seeds and a moderate use of nitrogen. In an early stage: killing of the culture. In general the use of resistant crops and/or untainted seeds will be more expensive for the farmer but at the same time will save him the expenditure for the chemical pesticides.

5.3 Assumptions used to evaluate the effects of an EU wide levy

Before presenting the results of the pesticide chains, it is important to understand the assumptions which have been used to evaluate the main economic and environmental effects of an EU wide levy. The assumptions relate to the economic model used, to the charge basis, the charge rate, the price elasticity's of demand and the extent of substitution and complementary between the pesticides. Below these assumptions will be briefly elaborated.

Model assumptions

One major assumption of the neo-classical economic model used is the rationality of the farmer with respect to his use of pesticides. This means that it is assumed that a farmer will use pesticides to the point where the marginal costs of it equal the marginal benefits. Consequently, the economic model used disregards any possible overuse of pesticides at the farm.

Charge basis

Basically one can choose between the retail price of the pesticides and the price of the active ingredients of the pesticides, to put a levy on. Due to a lack of data on the retail prices of the pesticide used in the chains, it was not possible to base the levy on this value. An alternative, which is used in the chains, was to base the levy on the active ingredients of the pesticides. This type of information was available for all pesticide chains.

Charge rate

In the analysis of the pesticide chains two levy scenarios are distinguished. In the first *scenario* all active ingredients of the pesticides are treated the same way. This means that the levy rate for the various active ingredients are equal, irrespective of possible different environmental hazards. As a first step, for all pesticide chains a 20% levy on active ingredients is assumed. Note that this rate lies between the existing rates in Sweden and Denmark.

In the second *scenario* the levy on the active ingredients of the pesticides depends on the environmental hazards of these pesticides. As described in section 4.2, the pesticides used in agriculture have been classified into seven classes. The rate of the levy is based on the following, arbitrary procedure:

- the levy on active ingredients of pesticides belonging to the 'middle' classes III, IV and V is 20% (the environmental effects of these active ingredients are regarded average and therefore equal to the levy of the first scenario);
- the levy on active ingredients of pesticides belonging in the 'hazardous' classes I or II is 40%, twice as high as the average levy;

- finally, the levy on active ingredients of pesticides belonging to the 'harmless' classes VI or VII is 10%, twice as low as the average levy.

Price elasticity's of demand

The economic effects of a levy strongly depend on the *price elasticity of demand* of the pesticides. Because the economic model focuses on the direct effects of an EU wide levy of pesticides, a short-term price elasticity of demand of pesticides is assumed. On the basis of the studies presented in Table 4.1, the following ranges of price elasticity's of demand have been chosen for the different types of pesticides (see Table 5.2).

Table 5.2 Chosen range of price elasticity's of demand of pesticides: divided by type of pesticide

type of pesticide	low price elasticity of demand	high price elasticity of demand
fungicides	- 0.4	- 0.8
herbicides	- 0.7	- 0.9
insecticides	- 0.3	- 0.8

Source: EIM

In analysing the effects of an EU wide levy on pesticides, for each pesticide chain one price elasticity of demand was chosen. The following procedure was followed: if there are none or only few alternative plant protection devices available in the pesticide chain the low price elasticity was chosen, if there are many different alternatives available the high elasticity was chosen. The underlying reason is simple: by introducing an EU wide levy on pesticides possible alternatives will become relatively cheaper, which will lead to a higher price elasticity of demand.

It is as yet unclear whether the above set of price elasticity's of demand reflect reality. For example, one could argue that the studies presented in Table 4.1 are biased towards the (typical?) characteristics of the northern Member States of the European Union. On the other hand, one should not disregard the close resemblance across the outcomes of the fifteen studies.

Substitution and complementary between pesticides

Besides the price elasticity of demand, the effects of an EU wide levy depend heavily on the extent of *substitution* or *complementary* between the pesticides used at the farm. Complementary means that the use of one pesticide (active ingredient) has a clear connection with the use of another pesticide (active ingredient). Hence, in the case of complementary different levies on the active ingredients will have little impact. In the case of substitution, a higher levy on one pesticide (active ingredient) will make another pesticide (active ingredient) relatively cheaper and more attractive. This will have a positive impact on the effects of a differentiated levy.

Unfortunately, there was only little information available on the extent of complementary and substitution between the active ingredients for the pesticide chains chosen. Only for the chains directed to the Netherlands this information could be obtained. Hence, for the remaining pesticide chains assumptions on the extent of complementary and substitution had to be made. As a first step, it was assumed that the active ingredients in these pesticide chains are substitutes of each other rather than complements.

5.4 Results of the pesticide chains

5.4.1 Introduction

In this chapter, for each pesticide chain, the main effects of an EU wide levy on pesticides are presented. The results will be presented in a pre-determined format, First, relevant background information on the pesticide chain is given. Second, the decisions on the price elasticity of demand, substitution and complementary and the two levy scenarios are explained. Third, the economic effects of the levy are displayed and discussed. Finally, the environmental effects of the levy are presented. Conclusive statements on the results of all pesticide chains are given in section 5.5.

The following economic effects of a levy on pesticides are included in the various Tables:

- *the change in the use of pesticides*: this change depends on the rate of the I levy and the assumed price elasticity of demand;
- *the change in pesticide costs*: this change depends on the change in the use of the pesticides and the rate of the levy;
- *the change in total costs*: this change depends on the change in pesticide costs and the cost-share of pesticides;
- *the change in revenues*: this change depends on the revenues-share of the pesticides and the change in the use of pesticides;
- *the change in gross margin per farmer*: this change depends on the change in total revenues, the change in total costs and the number of farms;
- *revenues of the levy*: these depend on the rate of the levy, the price of the active ingredients and the use of the pesticides.

5.4.2 Chain 1: Fungicides in lettuce in England and Wales

Fungicides in the cultivation of lettuce in England and Wales are used to protect lettuce against mildew. The most important chemical means used by the farmers, are propamocarb-hydrocloride (killing of fungi), fosetyl-aluminium (stimulation of plants' natural resistance), tolclofos-methyl and thiram (blockade of metabolism in fungi). The total usage of these active ingredients in the cultivation of lettuce in England and Wales is 8, 4, 3 and 2 ton per year, respectively. The farmers involved have a relatively high efficiency of using the fungicides: i.e., the estimated costs are about 2% of the total yield.

For this pesticide chain a price elasticity of demand of - 0.4 is assumed. This elasticity is at the lower bound (see Table 5.2). It was chosen because the pesticide experts in the UK did not report any plant protection alternatives to the use of the above-mentioned active ingredients. Moreover, substitution was assumed between the four active ingredients. As thiram is regarded very hazardous to the aquatic environment, it was classified with a 'I'. Hence, the levy for this active ingredient was set at 40% instead of 20%. Fosetyl-aluminium and tolclofos-methyl are regarded less hazardous to the environment, consequently the levy for these active ingredients was set at 10%, thereby encouraging a substitution from thiram to fosetyl-aluminium and tolclofos-methyl.

Table 5.3 presents the economic and environmental effects of the two levy scenarios in the pesticide chain fungicides in lettuce in England and Wales.

From this Table one can see that in levy scenario 1 the levy of 20% results in a decrease in the use of pesticides of 8%. Compared to the other pesticide chains this reduction is relatively low. Due to the levy the costs of fungicides at the farms increase by 10%. Pesticide costs at the farm rise because the decrease in using the fungicides is not enough to offset the price increase induced by the levy. The change in total costs is relatively small due to a high efficiency of pesticide use (i.e., the low share of pesticides costs). The gross margin per farmer reduces by € 148.

The overall effect of the levy system in scenario 2 is less than in scenario 1. Compared to the first scenario, the change in pesticide use increases by 1%, whereas the costs of pesticides decrease by nearly 2%.The differences can be explained by the lower levy of 10% on two of the four active ingredients. Due to the low share of pesticide costs in total yields, there are no large differences between the scenarios with respect to the total costs, revenues and gross margin.

Whereas the economic effects of the levy in the two scenarios are more or less the same, this is not the case for the environmental effects. In the first scenario, the four active ingredients are reduced by 8% each. In the second scenario, however, the (risky) active ingredient thiram is reduced by 16%, whereas the active ingredients fosetyl-aluminium and tolclofos-methyl are reduced by 4%. Whereas these changes could be beneficial to the local and regional environment, it is difficult to choose between the two scenarios as the overall impact of scenario 2 is less than scenario 1.

Table 5.3. Economic and environmental effects of a levy on fungicides in lettuce in England and Wales

Active ingredients	category	use in tons	price / ton
A. Propamocarb-hydrochloride	III	8	€ 75,000
B. Fosetyl-aluminium	VII	4	€ 35,000
C. Tolclofos-methyl	VI	3	€ 70,000
D. Thiram	I	2	€ 10,000
Cost share (pesticides)		2% of total yield	
Assumptions			
Price elasticity of demand		- 0.4	
Levy scenario 1		A, B, C, D : 20%	
Levy scenario 2		A:20%; B:10%; C:10%; D:40%	
Economic effects		scenario 1	scenario 2
Change in use of pesticides		- 8.0%	- 7.1%
Change in costs of pesticides		+ 10.4%	+ 8.8%
Change in total costs		+ 0.2%	+ 0.2%
Change in revenues		- 0.2%	- 0.1%
Change in gross margin per farmer		€ - 148	€ - 124
Revenues of the levy		€ 175,000	€ 147,000
Ecological effects		scenario 1	scenario 2
A. Propamocarb-hydrochloride		- 8.0%	- 8.0%
B. Fosetyl-aluminium		- 8.0%	- 4.0%
C. Tolclofos-methyl		- 8.0%	- 4.0%
D. Thiram		- 8.0%	- 16.0%

Source: EIM

5.4.3 Chain 2: Fungicides in green peppers in Almeria (Spain)

Alike lettuce, fungicides in the cultivation of green peppers in Almeria (Spain) are used to protect the crop against mildew. The four most important chemical means used by the farmers in Almeria are ethirimol, triflumizole, pyrifenox and triadimenol. The total use of these active ingredients in the cultivation of green peppers is 6, 11, 9 and 4 ton a year, respectively. In 1996 the total area of green peppers in Almeria was estimated at 7,700 hectares. The farmers involved have a relatively high efficiency of using the fungicides: i.e., the estimated costs are about 2% of the total yield.

Just as in the preceding pesticide chain, a price elasticity of demand of - 0.4 is assumed here. This elasticity is at the lower bound (see Table 5.2). It was chosen because the pesticide experts in Spain did not report any plant protection alternatives to the use of the above-mentioned active ingredients. Moreover, substitution was assumed between the four active ingredients. Of the active ingredients, pyrifenox is regarded the most hazardous to the environment (classification II). Hence, the levy for this active ingredient was set at 40% in levy scenario 2. As ethirimol is regarded the less hazardous to the environment, the levy for this active ingredient was set at 10%, thus encouraging a substitution from pyrifenox.

Table 5.4 presents the economic and environmental effects of the two levy scenarios in the pesticide chain fungicides in green peppers in Almeria.

Table 5.4 Economic and environmental effects of a levy on fungicides in green peppers in Almeria

Active ingredients fungicides	category	use in tons	price / ton
A. Ethirimol	VII	6	€ 7,000
B. Triflumizole	V	11	€ 16,000
C. Pyrifenox	II	9	€ 16,000
D. Triadimenol	III	4	€ 18,000
Cost share (pesticides)		2% of total yield	
Assumptions			
Price elasticity		- 0.4	
Levy scenario 1		A, B, C, D: 20%	
Levy scenario 2		A:.10%; B: 20%; C:40%; D 20%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 8.0%	- 9.5%
Change in costs of pesticides		+10.4%	+ 12.3%
Change in total costs		+ 0.2%	+ 0.2%
Change in revenues		- 0.2%	- 0.2%
Change in gross margin per farmer		€ - 51	€ - 63
Revenues of the levy		€ 79,000	€ 96,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Ethirimol		- 8.0%	- 4.0%
B. Triflumizole		- 8.0%	- 8.0%
C. Pyrifenox		- 8.0%	- 16.0%
D. Triadimenol		- 8.0%	- 8.0%

Source: EIM

Alike the pesticide chain on fungicides in lettuce, the levy of 20% results in a decrease in the use of pesticides of 8%. Due to the levy, and the low price elasticity of demand, the costs of pesticides at the farms increase by some 10%. Pesticide costs at the farm rise because the decrease in using the fungicides is not enough to offset the price increase induced by the levy. The change in total costs is modest due to a high efficiency of pesticide use. Compared to the first pesticide chain, the change in gross margin per farmer is relatively small: € 51.

The effect of the different levies in scenario 2 on the use of pesticides is greater than in scenario 1. Compared to the first scenario, the change in pesticide use decreases by almost 2% whereas the costs of pesticides increases by nearly 2%.These differences can be explained by the higher levy of 40% on the active ingredient pyrifenox. There are no differences between the two scenarios with respect to the total costs and revenues.

In levy scenario 2 the decrease in the use of pyrifenox (classification II) is twice as high as the decrease in levy scenario 1. This change will be beneficial to the local and regional environment. Together with the increased overall reduction in the use of pesticides, this beneficial change seems to favour the use of a differentiated levy system in the pesticide chain 'fungicides in the cultivation of green peppers in Almeria'.

5.4.4 Chain 3, 4: Insecticides in cucumbers in England, Wales and the Netherlands

In this section, the two pesticide chains on insecticides in the cultivation of cucumbers are taken together. First the results of both pesticide chains will be presented separately, then general conclusions will be drawn.

Insecticides in the cultivation of cucumber in England, Wales and the Netherlands are used to protect this crop against insects. The most important chemical means used in England and Wales are nicotine, dichlorvos, fenbutatin and propoxur. The use of these active ingredients is 0.1 ton a year, each. In the Netherlands, dichlorvos, methiocarb and methomyl are used. The use of these active ingredients is 3, 1 and 1 ton a year, respectively. Farmers in England, Wales and the Netherlands have a relatively high efficiency of using insecticides: i.e., the estimated costs are about 2% of the total yield.

For both pesticide chains, a price elasticity of demand of - 0.8 is assumed. This elasticity lies at the upper bound (see Table 5.2). This elasticity was chosen because the pesticide experts in the United Kingdom and the Netherlands reported various biological crop protection alternatives, such as using the mite *Amblyseius cucumeris* against *Thrips tabaci*. Additional information from the Netherlands on the interaction of the active ingredients used in the cultivation of cucumbers indicates that the active ingredients dichorvos, methiocarb and methomyl are substitutes of each other. Consequently, substitution was also assumed for the pesticide chain in England and Wales. Of the six different active ingredients used in England, Wales and the Netherlands, three of them are regarded as very hazardous to the environment: methomyl, nicotine and fenbutatin. Consequently, the levy for these active ingredient was set at 40% in levy scenario 2.

Table 5.5 present the economic and environmental effects of the two levy scenarios in the pesticide chain insecticides in cucumbers in England and Wales.

Table 5.5 Economic and environmental effects of a levy on insecticides in cucumber in England/ Wales

Active ingredients fungicides	category	use in tons	price / ton
A. Nicotine	I	0.1	€ 45,000
B. Dichlorvos	V	0.1	€ 45,000
C. Fenbutatin	I	0.1	€ 230,000
D. Propoxur	VI	0.1	€ 180,000
Cost share (all active ingredients)		2% of total yield	
Assumptions			
Price elasticity		- 0.8	
Levy scenario 1		A, B, C, D: 20%	
Levy scenario 2		A:.40%; B: 20%; C: 40%; D 10%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 16.0%	- 23.5%
Change in costs of pesticides		+ 0.8%	- 2.4%
Change in total costs		+ 0.02%	- 0.05%
Change in revenues		- 0.3%	- 0.5%
Change in gross margin per farmer		€ - 7	€ - 9
Revenues of the levy		€ 4,000	€ 7,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Nicotine		- 16.0%	- 32.0%
B. Dichlorvos		- 16.0%	- 16.0%
C. Fenbutatin		- 16.0%	- 32.0%
D. Propoxur		- 16.0%	- 8.0%

Source: EIM

As can be seen in this Table, the levy of 20% results in a decrease in the use of pesticides in the cultivation of cucumbers of 16%. Due to the levy, and the assumed high price elasticity of demand, the costs of pesticides at the farms increase by 1%. The change in total costs, revenues and gross margin is small.

The overall effect of the different levies in scenario 2 on the use of pesticides is 50% higher than in scenario 1. Compared to the first scenario, the change in pesticide use decreases by 7.5%. This difference can be explained by the higher levy of 40% on two of the four active ingredients. It is remarkable to see that the cost of pesticides at the farm diminishes by some 2% due to the price increase. The underlying reason for this lies in the fact that the (negative) cross product of the volume and price effect of the levy - the cross effect - is greater than the summing up of the two effects. The same argumentation applies to the (positive) change in total costs (seen from the perspective of the farmer).

Table 5.6 present the economic and environmental effects of the two levy scenarios in the pesticide chain insecticides in cucumbers in the Netherlands.

Table 5.6. Economic and environmental effects of a levy on insecticides in cucumber in the Netherlands

Active ingredients fungicides	category	use in tons	price / ton
A. Dichlorvos	V	3	€ 45,000
B. Methiocarb	V	1	€ 120,000
C. Methomyl	I	1	€ 90,000
Cost share (pesticides)		2% of total yield	
Assumptions			
Price elasticity		- 0.8	
Levy scenario 1		A, B, C: 20%	
Levy scenario 2		A:.20%; B: 20%; C: 40%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 16.0%	- 19.0%
Change in costs of pesticides		+ 0.8%	- 0.5%
Change in total costs		+ 0.02%	- 0,01%
Change in revenues		- 0.3%	- 0.4%
Change in gross margin per farmer		€ - 299	€ - 343
Revenues of the levy		€ 63,000	€ 72,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Dichlorvos		- 16.0%	- 16.0%
B. Methiocarb		- 16.0%	- 16.0%
C. Methomyl		- 16.0%	- 32.0%

Source: EIM

Alike the situation in England and Wales, the levy of 20% in the cultivation of cucumbers in the Netherlands result in a decrease in the use of the pesticides of 16%. Due to the levy, and the assumed high price elasticity of demand, the costs of pesticides at the farms increase by 1%. The change in total costs, revenues and gross margin is again small. Yet, the change in gross margin per farmer is substantial when compared to the situation in England and Wales: € 299 versus € 7.

Just as in England and Wales, the overall effect on the use of pesticides of a differentiated levy in scenario 2 is higher than in scenario 1. Compared to the first scenario, the change in pesticide use decreases by 3%. The difference can be explained by the higher levy of 40% on one of the three active ingredients. Alike the situation in England and Wales the cost of pesticides at the farm diminishes by some 2% due to the levy. The underlying reason for this result has been explained above. With respect to the other economic criteria there are only small differences between the two scenarios.

In both pesticide chains on fungicides in the cultivation of cucumbers the differentiated levy system resulted in a greater decrease in the overall use of the insecticides as well as in the use of the most hazardous insecticides. Both facts favours the use of (different) levies based on the environmental hazards of the insecticides. More generally, the close similarities in these pesticide chains suggest that the outcomes may be generalised to some higher level of aggregation. In this case, the results may be generalised up to the case of insecticides in the cultivation of cucumbers in the European Union, and hopefully to the use of insecticides in the horticultural sector of the Community.

5.4.5 Chain 5, 6: Fungicides in potatoes in Sweden and the Netherlands

In this section, the two pesticide chains on fungicides in the cultivation of potatoes are taken together. First the results of both pesticide chains will be presented separately, then general conclusions will be drawn.

Fungicides in the cultivation of potatoes in Sweden and the Netherlands are used to protect this crop against *Phytophthora infestans*, causing potato disease. The most important chemical means used in Sweden are fluazinam and mancozeb. The usage of these active ingredients is 26 and 39 ton a year, respectively. In the Netherlands four active ingredients are used: triphenyltinetate, mancozeb, mane and fluazinam. The usage of these active ingredients is 126, 511, 557 and 115 ton a year, respectively. Farmers in Sweden have a higher efficiency of using fungicides in potatoes than farmers in Netherlands: the estimated costs of the pesticides are about 2% and 5% of the total yield, respectively.

In both pesticide chains a price elasticity of demand of - 0.8 is assumed. This elasticity is at the upper bound (see Table 5.2). It was chosen because the pesticide experts in Sweden and the Netherlands reported various crop protection alternatives to the use of fungicides, such as the use of uninfected seeds, the use of resistant crops, the use of unattained seeds, and the killing of the culture in an early stage. Additional information from the Netherlands on the interaction of the active ingredients used in the cultivation of potatoes indicates that two of the active ingredients used by the farmers are complementary to each other: triphenyltinetate and maneb. In other words, a reduction in one of these active ingredients is accompanied by the same reduction in the other active ingredient. Because the farmers in Sweden use the other two active ingredients of the Netherlands - fluazinam and mancozeb -, it was reasonable to assume substitution there. Of the four different active ingredients used only triphenyltinetate is regarded very hazardous to the environment (category I). Consequently, the levy for this active ingredient was set at 40% in levy scenario 2.

Table 5.7 present the economic and environmental effects of the two levy scenarios in the pesticide chain fungicides in potatoes in Sweden.

Table 5.7 Economic and environmental effects of a levy on fungicides in potatoes in Sweden

Active ingredients fungicides	category	use in tons	price / ton
A. Fluazinam	V	26	€ 120,000
B. Mancozeb	VI	39	€ 30,000
Cost share (pesticides)		2% of total yield	
Assumptions			
Price elasticity		- 0.8	
Levy scenario 1		A, B : 20%	
Levy scenario 2		A:.20%; B: 10%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 16.0%	- 11.2%
Change in costs of pesticides		+ 0.8%	+ 0.9%
Change in total costs		+ 0.02%	+ 0.02%
Change in revenues		- 0.3%	- 0.3%
Change in gross margin per farmer		€ - 51	€ - 44
Revenues of the levy		€ 712,000	€ 622,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Fluazinam		- 16.0%	- 16.0%
B. Mancozeb		- 16.0%	- 8.0%

Source: EIM

As can be seen in Table 5.7, the levy of 20% results in a decrease in the use of pesticides in the cultivation of potatoes of 16%. Due to the levy and the assumed high price elasticity of demand the costs of pesticides at the farm slightly increases by 1%. The change in total costs is small due to the high efficiency of pesticide use. The change in gross margin per farmer is € 51.

In the second levy scenario, the impact of the levy on the use of fungicides in the cultivation of potatoes is 11%, less than the reduction in scenario 1. The reason is fact that one of the two active ingredients in this scenario has a levy of 10% instead of 20%. The influence on the other economic parameters is almost the same as in the first levy scenario.

Table 5.8 presents the economic and environmental effects of the two levy scenarios in the pesticide chain fungicides in potatoes in the Netherlands.

Table 5.8 Economic and environmental effects of a levy on fungicides in potatoes in the Netherlands

Active ingredients fungicides	category	use in tons	price / ton
A. Triphenyltinetate	I	126	€ 40,000
B. Mancozeb	VI	511	€ 7,000
C. Maneb	V	557	€ 5,000
D. Fluazinam	V	115	€ 90,000
Cost share (pesticides)		5% of total yield	
Assumptions			
Price elasticity		- 0.8	
Levy scenario 1		A, B, C, D : 20%	
Levy scenario 2		A: 40%; B: 10%; C: 20%; D 20%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 16%	- 18.3%
Change in costs of pesticides		+ 0.8%	- 0.2%
Change in total costs		+ 0.05%	- 0.01%
Change in revenues		- 1.0%	- 1.1%
Change in gross margin per farmer		€ - 365	€ - 396
Revenues of the levy		€ 3,654,000	€ 3,964,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Triphenyltinetate		- 16.0%	- 26.0%
B. Mancozeb		- 16.0%	- 8.0%
C. Maneb		- 16.0%	- 26.0%
D. Fluazinam		- 16.0%	- 16.0%

Source: EIM

Just as in the pesticide chain on fungicides in potatoes in Sweden, the levy of 20% results in a decrease in the use of pesticides of 16%. Due to the levy and the assumed high price elasticity of demand the costs of pesticides at the farm slightly increases by 1%. The change in total costs is almost zero due to the high efficiency of pesticide use. The change in gross margin per farmer is much higher than in the case of Sweden: € 365 versus € 51. Hence, these outcomes clearly show that the same levy for the same type of pesticide used in the same type of crop could have different effects to farmers in different regions.

In contrast to the situation in Sweden, the overall effect of a differentiated levy system on the use of fungicides in potatoes is higher than in scenario 1. Compared to the first scenario, the change in pesticide use decreases by 2%. This difference can be explained by the higher levy of 40% on triphenyltinetate and the accompanied reduction in maneb due to their complementary (and despite the fact that the levy on maneb is 20%).The costs of pesticides in scenario 2 diminish by 0.2%. The underlying reason for this lies again in the fact that the (negative) cross product of the volume and price effect of the levy - the cross effect - is somewhat greater than the summing up of the two separate effects. Finally, it is worth noting that the revenues of a levy on potatoes in the Netherlands are quite high, about € 4 million. This is because many farmers in Holland cultivate potatoes.

From an environmental point of view, it is difficult to provide a clear statement on the two levy scenarios. In Sweden, the undifferentiated levy system results in a greater decrease in the use of pesticides than the differentiated scenario. This is because the active ingredients involved are not considered very hazardous to the environment. Hence, they are levied too much in the first levy scenario. For the Netherlands, it is tempting to conclude that a differentiated levy system should be used above an undifferentiated system. However, one should take into account that the results are positively influenced by the fact that the most hazardous pesticide - triphenyltinetate - is complementary to another less hazardous pesticide: maneb. More generally, it seems that information on the complementary and substitution of the active ingredients is crucial in getting a satisfactory notion of the effects - economic and environmental - of an EU wide levy on pesticides. Unfortunately, this information is not easy to obtain.

5.4.6 Chain 7: Herbicides in corn in the Netherlands

Herbicides in the cultivation of corn in the Netherlands are used to protect the crop from weeds. The three most important chemical means used by the farmers are atrazin, bentozon and pyridate. The use of these active ingredients is 154, 100 and 57 ton a year, respectively. Compared to the other pesticide chains, the farmers involved have a relatively poor efficiency of using the pesticides: i.e., the estimated costs are about 6% of the total yield.

In this pesticide chain a price elasticity of demand of - 0.9 is assumed. This elasticity is at the upper bound (see Table 5.2). It was chosen because the pesticide experts in the Netherlands reported various crop protection alternatives, such as mechanical weed control[14]. Additional information from the Netherlands on the interaction of the active ingredi-

[14] Mechanical weed control in corn is gaining importance. In 1995 mechanical weed control was applied at about 26% of the area used for corn cultivation. This was caused by stimulation of specialised equipment for this crop (weed harrow). A 100% mechanical treatment of the field, however, is often practically impossible to perform, due to the fact that the timing of such activity is extremely important and that the farmer often hires some contract workers to do the job. The combination of an exact timing of mechanical weed control, a perfectly prepared crop field and the time schedule of contract workers appears to be impossible in practice. Therefore at present growing interest exists for the combination of mechanical weed control (weed harrow, two times) before the rise of corn plants, and chemical treatment (in low doses) directly after

ents used in the cultivation of corn indicates that two of the active ingredients used by the farmers are complementary to each other: atrazin and pyridate. Atrazin is also regarded the most hazardous of the three active ingredients: i.e., seen from the environmental point of view. Pyridate is much less hazardous to the environment. Due to their complementary, it is difficult to stimulate a substitution between these two active ingredients.

Table 5.9 presents the economic and environmental effects of the two levy scenarios in the pesticide chain herbicides in corn in the Netherlands.

Table 5.9 Economic and environmental effects of a levy on herbicides in corn in the Netherlands

Active ingredients fungicides	category	use in tons	price / ton
A. Atrazin	II	154	€ 10,000
B. Bentazon	III	100	€ 35,000
C. Pyridate	VII	57	€ 55,000
Cost share (pesticides)		6% of total yield	
Assumptions			
Price elasticity		- 0.9	
Levy scenario 1		A, B, C: 20%	
Levy scenario 2		A:40%; B:20%; C:10%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 18%	- 18%
Change in costs of pesticides		- 1.6%	- 1,6%
Change in total costs		- 0.1%	- 0.1%
Change in revenues		- 1.0%	- 1.0%
Change in gross margin per farmer		€ - 267	€ - 267
Revenues of the levy		€ 1,337,000	€ 1,335,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Atrazin		- 18.0%	- 18.0%
B. Bentazon		- 18.0%	- 18.0%
C. Pyridate		- 18.0%	- 18.0%

Source: EIM

Due to the assumed high price elasticity of demand, the levy of 20% results in a decrease in the use of pesticides of 18%. The costs of pesticides in scenario 1 diminish by almost 2%. The underlying reason for this lies in the high cross effect of the volume and price

rise: integrated pesticide management. This integrated pesticide management in corn not only results in a higher crop yield per hectare but also reduces the costs per hectare up to € 40 per ha compared to the traditional chemical treatment in advised doses.

effect of the levy. Also the change in total costs is positive, seen from the perspective of the farmer. The change in gross margin is, however, negative: minus € 267.

Because of the complementary between atrazin and pyridate, the outcomes of the second levy scenario are identical to the outcomes of the first scenario. In fact, the high levy of 40% on atrazin is counterbalanced by the low levy of 10% on pyridate.

5.4.7 Chain 8: Herbicides in winter barley in England and Wales

Herbicides in the cultivation of winter barley in England and Wales are used to protect the crop from weeds. The four most important chemical means used by the farmers are isoproturon, pendimethalin, mecoprop and tri-allate. The use of these active ingredients is 719, 125, 82, 68 ton a year, respectively. Compared to the other pesticide chains, the farmers involved have a relatively poor efficiency of using the herbicides: i.e., the estimated costs are about 5% of the total yield.

In this pesticide chain a price elasticity of demand of - 0.7 is assumed. This elasticity is at the lower bound (see Table 5.2). It was chosen because the pesticide experts in the United Kingdom did not report any crop protection alternatives to the use of pesticides. Moreover, substitution was assumed between the four active ingredients as no information on this topic was available. Of the active ingredients, pendimethalin and isoproturon are regarded the most hazardous to the environment (classification I and II, respectively). Hence, the levies for these active ingredients were set at 40% in levy scenario 2. Since mecoprop is regarded less hazardous to the environment, the levy for this active ingredient was set at 10%, encouraging a substitution from pendimethalin and isoproturon.

Table 5.10 presents the economic and environmental effects of the two levy scenarios in the pesticide chain herbicides in winter barley in England and Wales.

From this Table it can be seen that in levy scenario 1 the levy of 20% results in a decrease in the use of pesticides of 14%. Due to this levy the costs of pesticides at the farms increase by 3%. Pesticide costs rise because the decrease in using the fungicides is not enough to offset the price increase induced by the levy. The changes in total costs, revenues and gross margin per farmer are relatively small, however.

The overall effect of the differentiated levy in scenario 2 on the use of pesticides is much higher than in scenario 1. Compared to the first scenario, the change in pesticide use decreases by 11% whereas the costs of pesticides at the farm decreases only by 2%. The differences can be explained by the higher levy of 40% on two of the four active ingredients. Due to the low share of pesticide costs in total yields, there are no large differences between the two scenarios with respect to the total costs, revenues and gross margin.

Whereas the economic effects of the two levy scenarios are more or less the same, this is not the case for the environmental effects. In the first scenario, all four active ingredients are reduced by 14%. In the second scenario, the risky active ingredients isoproturon and pendimethalin are reduced by 28%, whereas the less risky active ingredient mecoprop is reduced by 7%. These changes are beneficial to the local and regional environment. Hence, for this particular pesticide chain a differentiated levy system seems to be preferred over an ordinary levy system.

Table 5.10 Economic and environmental effects of a levy on herbicides in winter barley in England/Wales

Active ingredients fungicides	category	use in tons	price / ton
A. Isoproturon	II	719	€ 12,000
B. Pendimethalin	I	125	€ 28,000
C. Mecoprop	VII	82	€ 10,000
D. Tri-allate	V	68	€ 17,000
Cost share (pesticides)		5% of total yield	
Assumptions			
Price elasticity		-0.7	
Levy scenario 1		A, B, C, D: 20%	
Levy scenario 2		A:.40%; B: 40%; C:10%; D: 20%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 14.0%	- 25.3%
Change in costs of pesticides		+ 3.2%	+ 1.1%
Change in total costs		+ 0.2%	+ 0.1%
Change in revenues		- 0.7%	- 1.3%
Change in gross margin per farmer		€ - 23	€- 36
Revenues of the levy		€ 2,428,000	€ 3,771,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Isoproturon		- 14.0%	- 28.0%
B. Pendimethalin		- 14.0%	- 28.0%
C. Mecoprop		- 14.0%	- 7.0%
D. Tri-allate		- 14.0%	- 14.0%

Source: EIM

5.4.8 Chain 9: Fungicides in winter wheat in Sweden

Fungicides in the cultivation of winter wheat in Sweden are used to protect the crop against leaf and ear diseases (rust, mildew). The two most important chemical means used by the farmers are fenpropimorf and propiconazol. The usage of these active ingredients is 54 and 28 ton a year, respectively. The farmers involved have a relatively poor efficiency of using the pesticides: i.e., the estimated costs are about 4% of the total yield.

In this pesticide chain a price elasticity of demand of - 0.8 is assumed. This elasticity is at the upper bound (see Table 5.2). It was chosen because the pesticide experts in Sweden reported various crop protection alternatives: crop rotation, use of resistant strains and the use of uninfected seeds. Substitution was assumed between the two active ingredients as no additional information on this topic was available. Both active ingredients are regarded hazardous to the environment (classification II). Consequently, the levies for these active ingredients were set at 40% in levy scenario 2.

Table 5.11 presents the economic and environmental effects of the two levy scenarios in the pesticide chain on fungicides in winter wheat in Sweden.

Table 5.11 Economic and environmental effects of a levy on fungicides in winter wheat in Sweden

Active ingredients	category	use in tons	price / ton
A. Fenpropimorf	II	54	€ 40,000
B. Propiconazol	II	28	€ 240,000
Cost share (pesticides)		4% of total yield	
Assumptions			
Price elasticity		- 0.8	
Levy scenario 1		A, B : 20%	
Levy scenario 2		A:.40%; B: 40%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 16.0%	- 32.0%
Change in costs of pesticides		+ 0.8%	+ 4,8%
Change in total costs		+ 0.03%	- 0.2%
Change in revenues		- 0.6%	- 1.3%
Change in gross margin per farmer		€ - 72	€ - 117
Revenues of the levy		€ 1,476,000	€ 2,389,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Fenpropimorf		- 16.0%	- 32.0%
B. Propiconazol		- 16.0%	- 32.0%

Source: EIM

This Table shows that the levy of 20% in levy scenario 1 results in a decrease in the use of pesticides of 16%. Due to the levy and the assumed high price elasticity of demand the costs of pesticides at the farms increases only by 1%. Pesticide costs rise because the decrease in using the fungicides is not enough to offset the price increase induced by the levy. The changes in total costs, revenues and gross margin per farmer are relatively small in this scenario.

Because the levies in scenario 2 are twice as high as the levies in scenario 1, the effects on the use of pesticides in this scenario is also twice as high as the effects in scenario 1: 32% versus 16%. Due to the high levy and the assumed high price elasticity of demand the costs of pesticides in scenario 2 diminish by almost 5%. The underlying reason for this lies in the high cross effect of the volume and price effect of the levy. Also the change in total costs is positive, seen from the perspective of the farmer. The change in revenues and the change in gross margin are negative. The revenues of the levy in the second scenario are of course much higher than in the first scenario: € 1.5 million versus € 2.4 million.

The environmental effects of the second scenario are much better than those of the first scenario. Due to the fact that both active ingredients are considered very hazardous to the environment and are therefore levied by 40%, it is difficult to speak of a differentiated levy system.

5.4.9 Chain 10: Herbicides in public pavements and roads in the Netherlands

Besides the use of herbicides in agriculture these pesticides are also used to prevent public pavements and roads from destruction of weeds. This feature of herbicides forms the topic of the last pesticide chain evaluated in this study. The four most important chemical means are diuron, glyfosate, amitrol and simazin. The usage of these active ingredients by the Dutch municipalities is 11, 10, 2 and 0.5 ton a year, respectively. The general costs of weed treatment on public pavements and roads are estimated at € 0.05 per m^2, which corresponds to a cost share of about 2% of the variable costs.

In this pesticide chain a price elasticity of demand of - 0.9 is assumed. This elasticity is at the upper bound (see Table 5.2). It was chosen because the pesticide experts in the Netherlands reported four alternative crop protection devices to the use of herbicides:

- selective spraying by means of advanced equipment (with sensors);
- mechanical removal (brushing):
- physical removal (burning):
- physical removal (steam):

Additional information on the interaction of the active ingredients used in the weed treatment of public pavements and roads indicates that the four active ingredients are substitutes from each other. Of these active ingredients, diuron and amitrol are regarded the most hazardous for the environment (classification II). Glyfosate and simazin, however, are regarded less hazardous to the environment (classification IV). By using a differentiated levy system substitution between the various pesticides will be stimulated.

Table 5.12 presents the economic and environmental effects of the two levy scenarios in the pesticide chain on herbicides in public pavements and roads in the Netherlands.

Table 5.12 Economic and environmental effects of a levy on herbicides in roads in the Netherlands

Active ingredients fungicides	category	use in tons	price / ton
A. Diuron	II	11	€ 13,500
B. Glyfosate	III	10	€ 89,000
C. Amitrol	II	2	€ 89,000
D. Simazin	III	0.5	€ 9,000
Cost share (pesticides)		2% of variable costs	
Assumptions			
Price elasticity		- 0.9	
Levy scenario 1		A, B, C, D : 20%	
Levy scenario 2		A: 40%; B: 20%; C: 40%; D: 20%	
Economic Effects		levy scenario 1	levy scenario 2
Change in use of pesticides		- 18.0%	- 27.9%
Change in costs of pesticides		- 1.6%	- 3.9%
Change in total costs		- 0.1%	- 0.2%
Change in revenues per m^2		- 1.1%	- 1.4%
Change in gross margin per m^2		€ - 28	€ - 32
Revenues of the levy		€ 193,000	€ 221,000
Ecological Effects		levy scenario 1	levy scenario 2
A. Diuron		- 18.0%	- 36.0%
B. Glyfosate		- 18.0%	- 18.0%
C. Amitrol		- 18.0%	- 36.0%
D. Simazin		- 18.0%	- 18.0%

Source: EIM

From this Table it can be seen that the levy of 20% in levy scenario 1 results in a decrease in the use of pesticides of 18%. Due to the levy and the assumed high price elasticity of demand the costs of pesticides at the farms diminish by 2%. The changes in total costs, revenues and gross margin per m^2 are again small in this scenario.

In the second levy scenario, the levy has more impact. A reduction in the use of herbicides is established of 28%. The main reason for this are the higher levies which are applied on the active ingredients diuron and amitrol (40% instead of 20%). The costs of pesticides per m^2 diminish by almost 4% (due to a high cross effect) and the change in total costs by 0.2%. The revenues of the differentiated levy are estimated at € 221,000.

It should be noted that the outcomes of this pesticide chain should be generalised to the other Member States of the European Union, as the assumptions, treatments and chemical means are not specific for the Netherlands.

5.5 Conclusions

Before drawing the most relevant conclusions of the pesticide chains, Table 5.13 presents an overview of the key outcomes of the analyses.

Table 5.13 Overview of the key outcomes of the pesticide chains

Pesticide chains	*change in use of pesticides*		*change in total costs*		*change in gross margin per farmer (in Euro)*	
	scenario 1	*scenario 2*	*scenario 1*	*scenario 2*	*scenario 1*	*scenario 2*
1. *fungicides in lettuce in England and Wales*	- 8%	- 7%	+ 0.2%	+ 0.2%	- 148	- 124
2. *fungicides in green peppers in Almeria*	- 8%	- 10%	+ 0.2%	+ 0.2%	- 51	- 63
3. *insecticides in cucumbers in England and Wales*	- 16%	- 24%	+ 0.02%	- 0.05%	- 7	- 9
4. *insecticides in cucumbers in the Netherlands*	- 16%	- 19%	+ 0.02%	- 0.01%	- 299	- 343
5. *fungicides in potatoes in Sweden*	- 16%	- 11%	+ 0.02%	+ 0.02%	- 51	- 44
6. *fungicides in potatoes in the Netherlands*	- 16%	- 18%	+ 0.05%	- 0.01%	- 365	- 396
7. *herbicides in corn in the Netherlands*	- 18%	- 18%	- 0.1%	- 0.1%	- 267	- 267
8. *herbicides in winter barley in England and Wales*	- 14%	- 25%	+ 0.2%	+ 0.1%	- 23	- 36
9. *fungicides in winter wheat in Sweden*	- 16%	- 32%	+ 0.03%	- 0.2%	- 72	- 117
10. *herbicides in public pavements in the Netherlands*	- 18%	- 28%	- 0.1%	- 0.2%	- 28	- 32
General mean[(a)]	- 14%	- 18%	+ 0.1%	+ 0.02%	- 143	- 155

(a) The general means have been calculated on the basis of the first nine pesticide chains.

Source: EIM

From this Table it can be seen that the decrease in the use of the pesticides lies between 8% and 18% for the first levy scenario, and between 7% and 32% for the second levy scenario. The increase in total costs at the farms due to the levy lies between + 0.2% and

- 0.1% for the first levy scenario and between + 0.2% and - 0.2% for the differentiated levy scenario. Finally, the decrease in gross margin per farmer lies between € 7 and € 365 for the first scenario and between € 9 and € 396 for the differentiated levy scenario. On average, the latter scenario has a greater impact on the income of the farmers: € 155 Euro versus € 143 Euro in the first scenario.

The first conclusion which can be drawn on the basis of the outcomes is that a 20% levy on pesticides has a substantial impact on the use of pesticides in agriculture. From Table 5.13 a mean decrease (excluding the pesticide chain on public pavements) was computed of 14% for scenario 1 and 18% of scenario 2.

It should be noted that the reduction in the use of pesticides is somewhat biased to the positive side due to the frequently used assumption that the active ingredients are substitutes from each other. On the other hand, the reduction might be biased to the negative side as sometimes no alternatives to the use of pesticides were reported. This has led to a price elasticity which was at the lower bound in Table 5.2. In order to get a more reliable overview of the effectiveness of an EU wide levy more information on these two aspects should be gathered for the Member States. For example, in the chains for the Netherlands it was shown that additional information on the complementary between the active ingredients could have a substantial influence on the effects of the levy: i.e., compare the outcomes in the second levy scenario of pesticide chains no. 5 and 6.

The second conclusion which can be drawn on the basis of the outcomes is that the proposed differentiated levy system (10%, 20% and 40%) has a greater beneficial impact on the environment than the levy system which uses one overall levy (20%) (see Table 5.13).

Whereas it is tempting to propose such a differentiated levy system for the European Union, it should be noted that the classification used in this study is not undisputed. On the one hand, the classification only relates to the effects of the pesticides to the aquatic environment, on the other hand, for many pesticides it is still unknown what the precise effects to the environment are, especially in the long-term. More research on this topic is needed before a differentiated levy system can be actually implemented.

The third conclusion which can be drawn on the basis of the outcomes is that the economic effects of an EU wide levy of 20% are limited. From Table 5.13 a mean increase of the total costs (excluding the pesticide chain on public pavements) was computed of 0.1% for scenario 1 and 0.02% of scenario 2.

These effects are somewhat biased to the positive side due to a high efficiency in the use of the pesticides in the pesticide chains selected. Note that in some cases the total costs of a levy on pesticides even decrease (see, for example, pesticide chain no .7 in Table 5.13). The underlying reason for this results relates to a high price elasticity of demand (due to many alternative plant protection devices) combined with a substantial negative cross effect of the induced volume and price changes of the levy.

The fourth conclusion which can be drawn on the basis of the outcomes is that the gross margin per farmer differs largely across the pesticide chains (see Table 5.13): from € 7 in England and Wales (levy scenario 1 in pesticide chain 3) to € 396 in the Netherlands (levy scenario 2 in pesticide chain 6). Nevertheless, the mean decrease in gross margin between the two scenarios is small: € 143 versus € 155.

It should be noted that these income reductions have been calculated without a reimbursement of the revenues. By using an effective re-allocation of the revenues the reported decrease in gross margin should be reduced.

The fifth conclusion which can be drawn on the basis of the outcomes is that the differences in environmental effects are substantial across the pesticide chains when compared to the differences in economic effects. An important explanation relates to the different price elasticity's on demand. By using a high price elasticity of demand, important effects on the use of pesticides are realised. Because of the high efficiency in using the pesticides in agriculture - i.e., the estimated cost-shares in the nine pesticide chains lie between 2% and 6% - the economic effects of a high price elasticity of demand is largely neutralised.

The sixth conclusion which can be drawn on the basis of the outcomes is that the results of pesticide chains cannot be simply generalised to some higher level. Although the outcomes in the pesticide chains on insecticides in cucumbers seem to imply that these results could be generalised to some higher level of aggregation (to horticulture in the European Union?), the outcomes in the pesticide chains on fungicides in potatoes clearly show that the same levy for the same type of pesticide used in the same type of crop could have large different effects to farmers in different regions.

Again, more research on this topic is needed in order to be able to draw more useful conclusions on the potentiality of pesticide chains to generalise the outcomes from one pesticide chain to another.

Finally, it should be emphasised that the outcomes presented in Table 5.13 depend heavily on the assumptions stated in section 5.2. Most probably, other levy scenario's, other price elasticity's of demand and other assumptions on the extent of substitution or complementary between the pesticides will result in other values.

6 The contours of an EU wide regulatory framework for levies on pesticides

6.1 Introduction

This chapter presents a *charcoal sketch* of a European Union wide regulatory framework for levies on pesticides. That is, for several consequential elements of the regulatory framework, such as the charge base and the allocation of revenues, explicit propositions will be put forward. Yet, as the contemporary information on the regulation of pesticides by means of market-based instruments is too fragmented and brittle, it is not possible to draw the many details of the regulatory framework. In other words, a *blueprint* for a European Union wide regulatory framework on the taxation of pesticides, alike the one on energy products, cannot be designed yet.

In choosing the major consequential elements of a European Union wide regulatory framework for levies on pesticides, the existing Directive on the taxation of energy (Directives 91/12/EEC and 92/81/EEC) was used as a guideline. On the basis of *Article 1* to *Article 26* of this European environmental legislation, the following important elements have been selected:

- the products involved;
- the charge base;
- the charge rate;
- the imposition points;
- the allocation of revenues.

Below, in Table 6.1, four of these consequential elements have been put together. As for each element several alternatives are available, many variations exist in sketching a *charcoal* of a European Union wide regulatory framework for levies on pesticides. For example, from Table 6.1 it can be seen that the charge base of a levy on pesticides can be put on the hazards the pesticides cause to the environment, on the value of the pesticides (retail or wholesale price) or on the active ingredients of the pesticides. Moreover, the charge base selected could hold for all kinds of pesticides or could be differentiated to the different types of pesticides.

A similar variety of options is available for the charge rate (e.g. fixed rates, minimum rates, differentiated rates), the imposition points (e.g. industry, wholesalers, retailers, farmers) and institutions and targets to refund the revenues (e.g. European Union, individual Member States, agricultural sector, farmers involved, deficit reduction, supporting R & D).

Table 6.1 Variations in four consequential elements of an EU-wide regulatory framework on pesticides

Charge		Imposition	Refunding of revenues	
base	rate	points	organisation	target
environmental hazards	fixed	industry	EU	CAP
wholesale price	minimum	wholesalers	Member States	deficit reduction
retail price	differentiated	retailers	agricultural sector	direct payments per hectare;
active ingredients		farmers		crop premiums, innovation programs for industry
general, specific	high, medium, low		farmers involved	supporting environmental plant protection measures

Source: EIM

Table 6.1 exhibits that many European Union wide regulatory frameworks can be designed in combining the different charge bases, the different charge rates, the different imposition point systems and different allocations of revenues. For illustrative purposes, a subset of the possibilities are presented in Table 6.2.

Table 6.2 Some possible European Union wide regulatory frameworks on pesticides

System A	System B	System C
• *charge base*: retail price	• *charge base*: retail price	• *charge base*: active ingredients
• *charge rate*: minimum (medium)	• *charge rate*: fixed (high)	• *charge rate*: minimum (low)
• *imposition*: retailers	• *imposition*: farmers	• *imposition*: industry
• *revenues*: direct payments per hectare	• *revenues*: agricultural R & D	• *revenues*: CAP
System D	**System E**	**System F**
• *charge base*: env. risk	• *charge base*: env. risk	• *charge base*: wholesale price
• *charge rate*: fixed (high)	• *charge rate*: fixed (medium)	• *charge rate*: differentiated
• *imposition*: wholesalers	• *imposition*: industry	• *imposition*: wholesalers
• *revenues*: supporting environmental plant protection measures	• *revenues*: crop premiums	• *revenues*: support for integrated pesticide management

Source: EIM

The many options for designing an EU wide regulatory framework for levies on pesticides need to be ranked in order to select a best working system. On behalf of this, four criteria have been defined on which the possible frameworks will be evaluated. The criteria were established by noting that an *ideal* EU wide regulatory framework on pesticides, at least, *should* be:

- environmentally effective;

- economic efficient;
- acceptable for all those concerned;
- easy to accomplish.

In the next five sections the above-mentioned consequential elements will be dealt with separately (section 6.2 to 6.6). In each section, first the available options are presented, after which these options are evaluated against the criteria defined above. These judgements are partly based on the information presented in chapters 2, 3 and 4, partly based on the outcomes of the pesticide chains in chapter 5, and partly based on a review of new literature. At the end of each section clear proposals will be presented. Finally, on the basis of these proposals, a charcoal sketch of an EU wide regulatory framework for levies on pesticides is presented in section 6.7.

6.2 The products involved in the regulatory framework

It is important to define clearly which products fall under the framework. For example, in *Article 2* of the Council Directive on the taxation of energy products a precise list of products is specified, together with their 'CN-codes'.

With respect to the EU wide regulatory framework on pesticides, there are many possibilities. For example, the framework can be directed to all (registered) pesticides used in the agricultural sector of the European Union, or it can be directed to only those pesticides which are used in arable farming, horticulture, etceteras. It can also be directed to the pesticides used in meaningful water-collection areas or nature reserves. Another possibility is to direct the framework to the most risky pesticides, for example, those pesticides which were classified with a 'I' or 'II' in the pesticide chains. In Table 6.3 the above options are evaluated against the criteria defined in section 6.1.

In this Table a ✓ is used to denote that the option scores satisfactory towards the criteria. When possible a distinction is made between the options from ✓(most) to ✓(least).

Table 6.3 Four options with respect to the products involved in the EU wide regulatory framework

Options	Env. effect.	Easy to accom.	Acceptable	Ec. efficient
• all (registered) pesticides used in the agricultural sector	✓ *(most)*	✓	✓	✓
• all pesticides used in arable farming	✓	✓	✓ *(least)*	✓
• all pesticides used in meaningful water-collection areas	✓	✓ *(least)*	-	-
• only the most risky pesticides	✓	✓ *(least)*	-	-

Source: EIM

Table 6.3 displays that, from the point of view of environmentally effectiveness, all four options are feasible. However, compared to the other options, restricting the framework to all (registered) pesticides in the agricultural sector of the European Union is certainly the most effective. Directing the framework to only the most risky pesticides or to the pesticides used in meaningful water-collection areas are sub-optimal. As these two options are also very difficult to accomplish, they have not been evaluated further in Table 6.3.

With respect to the remaining two options, the acceptability of directing the framework to all (registered) pesticides will be higher than the option which focuses solely on the pesticide used in arable farming (or another sector within agriculture). Regarding the economic efficiency of the two options, there seem to be no major differences.

Consequently, on the basis of the evaluation presented in Table 6.3, it is proposed to define the European Union wide regulatory framework for levies to all (registered) pesticides used in the agricultural sector of the European Union.

6.3 The charge base of the EU wide levy

Alike the definition of the products involved in the framework, there are several possibilities to base on a European Union wide levy on pesticides. In Denmark, for example, the retail price of the pesticides is used as the base of the levy, whereas in Sweden the levy is put on the active ingredient of the pesticides.

Below, in Table 6.4, four options to base on a European Union wide levy on pesticides have been evaluated against the criteria set out in section 6.1. These options are: putting the levy on the environmental hazards caused by the pesticides, putting the levy on the dosage of the means, putting the levy on the value of the pesticides (by using the retail price or wholesale price), and putting the levy on the active ingredients of the pesticides.

Again in this Table a ✓ is used to denote that the option scores satisfactory towards the criteria. When possible a distinction is made between the options from ✓(most) to ✓(least). In the Table a ✗ is used to denote the fact that an option cannot satisfy the criterion.

Table 6.4 Four options with respect to the charge base of an EU wide levy

Options	Env. effect.	Easy to acc.	Acceptable	Ec. efficient
• environmental hazards	✓ *(most)*	✓ *(least)*	✓ *(most)*	✓
• dosage of the means	✓	✗	-	-
• value of the pesticides	✓	✓	✓	✓ *(more)*
• active ingredients	✓	✓	✓	✓

Source: EIM

Ideally, the EU wide levy should be based on the negative effects the pesticides pose to the environment. Whereas the contemporary literature on this issue (see, for example, Vos, 1998; Danish EPA, 1995; RSPB, 1998) claims that there are too many problems surrounding this option for it to be useful - for example, because of the difficulties in summating the various types of environmental damage into one single target -, the analysis in chapter 5 has shown that a classification directed to the aquatic environment is workable, albeit not indisputable. Therefore, the option of using the hazards of the pesticides as charge base of the EU wide levy is still regarded imaginable.

Of course, it is acknowledged that the easiness to accomplish such a classification will be the lowest of the stated options in Table 6.4. As mentioned in chapter 5, it seems that much more research on this topic is needed before a hazard-based differentiated levy system can be implemented in the European Union. On the other hand, the acceptability of basing the levy on the hazards the pesticides pose to the environment will probably be the highest of the four options. This is because there is a close natural connection between the base of the levy and the major aim of the European Union wide levy: improving the environment in the European Union.

Whereas putting the levy on the approved dosages of the means could also be environmentally effective, the discussion in *Article 416* of the Danish tax on pesticides (see Danish EPA, 1995, pp. 7-9) clearly indicates that implementing an effective and transparent levy on the basis of the approved dosages of the means is very difficult to realise: the main reason being the many variations in approved dosages for the same pesticides. Variations that depend on the crop and pest for which the pesticides are actually used. Hence, this option has not been further evaluated in Table 6.4.

It is ambiguous whether a levy which is based on the value of the pesticides will be more effective to the environment than a levy which is based on the active ingredients of the pesticides. This is because a levy which is put on the value of the pesticides favours the inexpensive pesticides which are usually also the older and more hazardous ones (see Danish EPA, 1995). By the same token, a levy which is based on the active ingredients of the pesticides does not necessarily relate to the environmental burden of the products. This is because the intensity of the means bought by the farmers can differ largely.[15] The argument in favour of putting the levy on the value of the pesticides - which is also used in Denmark - is that the cheaper, older and more hazardous products can be handled effectively by other policy instruments, such as speeding up Council Directive 91/414/EEC.[16]

[15] Vos (1998) has illustrated the above dilemma on the basis of two herbicides: *Roundup* and *Harmony*. The first product costs about € 8 per litter whereas the second product costs about € 2.000 per kg. Due to the fact that the amount of active ingredients in the first product is much higher than the amount in the second product, a levy based on active ingredients would have a large impact on the price of the first product but only a slight impact on the price of the second one.

[16] It should be noted that policy-makers in Sweden are thinking of changing their current levy on pesticides, which is based on active ingredients into a levy which is based of the value of pesticides.

With respect to the easiness of accomplishing the above-mentioned charge bases there seem to be no major differences. In fact, for both options there is some practical experience in Denmark and Sweden.

Regarding the economic efficiency of the options, an EU wide levy which is put on the value of the pesticides is considered somewhat more efficient than a levy which is put on the active ingredients. The main reason behind this position is the fact that putting the levy on the value of the pesticides will give a higher clarity to the farmers involved. Basically it is assumed that the more the farmers understand why (some of the) pesticides have become more expensive (for example, by using *environmental levy-labels*), the more they are prone to adjust their behaviour.

Consequently, on the basis of the evaluation presented in Table 6.4, it is proposed to put the European Union wide levy on the value of the pesticides. It is, however, difficult to determine whether the value-based levy should be revealed in the retail price of the pesticides or in the wholesale price. It seems reasonable that each Member State will be free to choose between these possibilities. This is because the infrastructure of distribution of the pesticides differs largely across the Member States (see Brouwer et al., 1994). For example, in countries where farmers buy their means mostly from the retailers, the levy should be put on the retail price (and vice versa)[17].

6.4 The charge rate of the EU wide levy

In *Article 6* and *7* of the regulatory framework on the taxation of energy, exact minimum levels of taxation are presented and differentiated to the various energy products (petrol, gas, etceteras). At this moment, it is not possible to be that precise for the taxation of pesticides.

In chapter 5 a levy of 20% was used per kg of active ingredient for all pesticides involved This levy was doubled for the most hazardous ones and halved for the least hazardous ones. Whereas this procedure and percentages have been used for illustrative reasons only, it should be noted that a levy of 20% falls within the current available evidence in the Member States of the European Union. In Sweden, for example, the pesticide tax entails a price increase of € 2 per kg of active ingredient, which results in a mean price increase of 5%. In Denmark, the charge rate entails a price increase of 37% for insecticides and 15% for herbicides and fungicides.

Another argument that favours the plausibility of an EU wide levy of about 20% stems from the information gathered by Brouwer et al. (1994) on the costs of pesticides as a percentage of the total yield. Table 6.5 below presents a condensed overview of the dif-

[17] In Table 6.1 the possibility was mentioned of varying the charge base among the different types of pesticides: for example, a value-based levy system for fungicides, a levy based on active ingredients for herbicides, etceteras. At the moment, there seems to be no major reason to construct such a differentiated charge base-system.

ferent cost shares of pesticides for the twelve Member States of the European Union, divided by 13 different crops. Next to the average cost shares of pesticides this Table also presents the lowest and highest cost shares (between brackets are presented the Member States involved) .

Table 6.5 Costs of pesticides as a percentage of the output (1989-1991) for the EU-12, divided by crops.

crops	*costs of pesticides as percentage of the output*		
	average	**lowest**	**highest**
arable crops			
soft wheat	7%	1% (Sp., Irl)	13% (Bel.)
barley	6%	1% (Sp., Irl.)	14% (Bel.)
potatoes	3%	0% (Irl., It.)	6% (Neth., Bel.)
sugar beet	5%	0% (Gre.)	10% (Bel.)
rape and turnip rape seed	7%	1% (It., Sp.)	11% (Ger.)
overall average	*6%*		
horticultural crops			
tomatoes	1%	0% (Bel., Fr., UK)	3% (It.)
other vegetables	1%	0% (Gre., Irl.)	2% (Bel., Dk., Ger., Sp., Por., UK, Neth.)
flowers and ornamental plants	0%	0% (Gre., Neth., Ger., Sp., Fr., It.)	2% (UK)
grapes for table wine	1%	1% (Gre., SP., Fr.)	25% (UK)
grapes for other wine	4%	0% (Lux.)	5% (Por., Fr.)
apples, pears and peaches	4%	0% (Sp., Irl.)	8% (Dk.)
other fruits	7%	0% (Irl.)	21% (It.)
citrus fruits	3%	1% (It.)	7% (Por.)
overall average	*3%*		

Source: Brouwer et al. (1994)

Table 6.5 shows that the costs of pesticides form only a minor part of the output of the crops. Only in the cultivation of grapes for table wine in the UK pesticide costs comprise a substantial part of the output (25%). The average cost share for all arable crops is 6% and for horticultural crops 3%. Hence, an EU wide levy of 20%, or even 30%, will have no major impacts on the total costs at the farm (see chapter 5). On the other hand, such a levy could have a great influence on the farmers' behaviour with respect to pesticide use.

In the regulatory framework on the taxation of energy products minimum levies have been introduced, divided by the various energy products. Such a *charge rate system* is only one of the possible options. In Table 6.6 four rate systems have been evaluated against the criteria set out in section 6.1. These systems are: fixed rates for all types of pesticides, minimum rates for all types of pesticides, fixed rates which are differentiated to specific types of pesticides and minimum rates which are differentiated to specific types of pesticides.

Table 6.6 Four options with respect to the charge rate system of an EU wide levy

Options	Env. effect.	Ec. efficient	Easy to acc.	Acceptable
• fixed rates (general)	✓	✓	✓ (more)	✓
• minimum rates (general)	✓	✓	✓ (more)	✓ (more)
• fixed rates (differentiated)	✓ (more)	✓ (more)	✓	✓
• minimum rates (differentiated)	✓ (more)	✓ (more)	✓	✓ (more)

Source: EIM

From Table 6.6 it can be seen that the effectiveness and efficiency of a differentiated charge rate is considered superior than those of a general rate. The reason behind this position relates to the outcomes presented in chapter 5: i.e., not all pesticides used in the agricultural sector are equally harmful to the environment. An adequate European Union wide regulatory framework for levies on pesticides should be able to charge the more hazardous pesticides more to stimulate the farmers' behaviour towards less hazardous pesticides of other plant protection devices.

Off course, imposing the same levy on all types of pesticides is easier to accomplish than imposing different levies to different types of pesticides. With respect to the acceptability of the four charge rate systems, a minimum rate system is considered more acceptable as individual Member States have more autonomy to adjust the system to their own needs.

Ideally, the charge rate should be differentiated towards the environmental hazards posed by the pesticides. In fact, the charge rate system introduced in chapter 5 could be used as a basis: i.e., double the rate for the most hazardous pesticides and halve it for the least hazardous pesticides. As an alternative, it is proposed to differentiate the charge rate towards the different types of pesticides: insecticides, fungicides, herbicides and other pesticides, alike the system in Denmark.

Consequently, on the basis of the evaluation presented in Table 6.6, it is proposed to select a charge rate system with minimum rates, preferably differentiated towards the environmental hazards of the pesticides. When this is not feasible, a differentiation towards the various types of pesticides could be a useful alternative.

6.5 Collecting the revenues of the EU wide levy

The collection of the revenues of the European Union wide levy should be chosen in such a way that both the administrative costs of the levy and possibilities of fraud are minimised. In this respect, Oskam et al. (1997) have compared the existing levy systems in the European Union on the basis of their administrative costs. In Denmark, the annual administrative costs have been estimated at 0.5% of the levy revenue, whereas in Sweden these costs were estimated ten times less. The relatively large difference between the two countries is mainly due to the complicated charge base system in Denmark, where each pesticide can or package has to be labelled with a fixed price including the levy and VAT.

In both countries, the companies that produce the pesticides act as intermediary for collecting and passing on the revenues of the levy. At this level the number of collection points is very limited, thereby simplifying the implementation and enforcement of the levy. All other imposition points - i.e., the farmers involved, the retailers, the wholesalers - are inferior to the industry, making the implementation of the levy more complicated and more difficult to enforce.

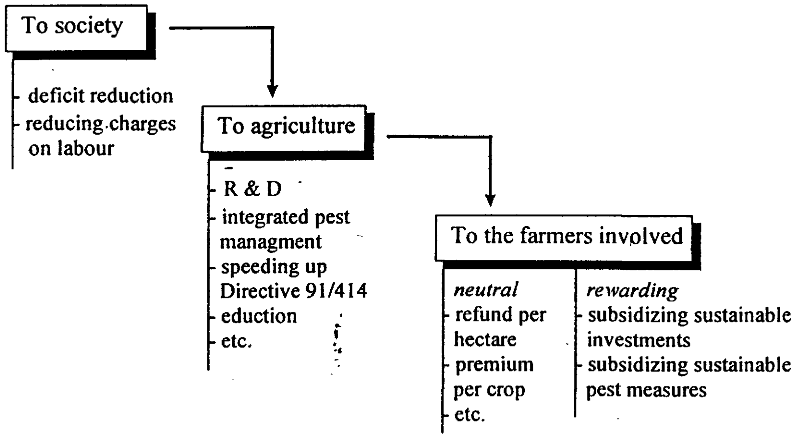
6.6 Reimbursing the revenues of the EU wide levy

There are various ways to allocate and use the revenues of an EU wide levy on pesticides. In a recent report to the Dutch Ministry of Housing, Spatial Planning and Environment, Vos (1998) distinguished three organisations to which the revenues could be allocated:

- to society (European Union or the Member States),
- to the agricultural sector;
- to the farmers involved (those who actually pay the levy).

For each organisation, Vos (1998) presented some possibilities to actually refund the revenues. For example, if the revenues are allocated to society, they can be used to reduce the budget deficit or to reduce the existing charges on labour. Yet, if the revenues are allocated to the agricultural sector, they can be used for pesticides related research and development activities, for speeding up the review of Council Directive 91/414/EEC, for programs that stimulate integrated pest management, for subsidies to innovate environmental-friendly pesticides, etceteras. With respect to allocating the revenues to the farmers involved, Vos (1998) distinguished two separate ways: the revenues can be refunded in a neutral way or they can be refunded in a rewarding way. The latter option includes, for example, subsidies on investments in sustainable plant protection devices. In Figure 6.1 the above-mentioned has been visualised.

Figure 6.1. Possibilities to refund the revenues of an EU wide levy on pesticides



Source: Vos (1998)

As using the revenues of the levy on pesticides for general purposes is not acceptable for those involved, this option has not been evaluated in Table 6.7. In this Table three different options are evaluated against the criteria set out in section 6.1: an allocation of the revenues to the agricultural sector using it for general purposes, an allocation to the farmers involved using it on a neutral base and an allocation of the revenues to the farmers involved thereby using it on a rewarding base.

Table 6.7 Three options with respect to allocating the revenues of an EU-wide levy

Options	Env. effect.	Ec. efficient	Easy to acc.	Acceptable
• agricultural sector (general purpose)	✓	✓	✓ *(most)*	✓ *(least)*
• farmers involved (neutral base)	✓ *(least)*	✓ *(least)*	✓	✓
• farmers involved (rewarding base)	✓	✓	✓ *(less)*	✓

Source: EIM

Of the three options presented in Table 6.7, the environmentally effectiveness of an allocation of the revenues to the farmers involved, using the revenues on a neutral base, is regarded the least effective. This is because this way of compensating does not contain a 'second' incentive - the first one being the levy - to the farmers to change their behaviour into a more environmental-friendly way. It is as yet unclear whether using the revenues of the levy for general purposes (option 1), such as research and development activities or education, is more effective than using the revenues to stimulate the farmers involved to some form of sustainable pesticide management (option 3). Much depends on the concrete use of the revenues and the amount of revenues.

The arguments used above can also be applied to the economic efficiency of the options. As option 1 and 3 stimulate farmers to further reduce or adjust their current pesticide use these options are regarded more efficient than option 2.

Allocating the revenues to the agricultural sector and using it for general purposes is more easy to accomplish than refunding the revenues to the farmers involved. In fact, using the revenues to reward farmers to change their behaviour in a more environmental-friendly way is probably the most difficult option to accomplish. For the Netherlands, Vos (1998) has studied the possibilities of using a levy on pesticides to reward four typical Dutch fiscal regulations. His results are promising. Nevertheless, the Dutch case cannot be simply duplicated to other Member States as there are important differences with respect to the (fiscal) regulations and legislature. If this option is regarded the most promising, it demands further research on possible regulations in the 15 Member States.

Finally, the acceptability of the first option is regarded the worst since some sectors in agriculture could be unjustifiably favoured in this option.

Consequently, on the basis of the evaluation presented in Table 6.7, it is proposed to reimburse the revenues of the EU wide levy to the farmers involved and to use the revenues for (fiscal) regulations in the agricultural sector which further stimulate farmers to change their behaviour in a more environmental-friendly way. Note that this kind of alternative is also ranked number 1 in the Communication from the Commission on *Environmental taxes and charges in the single market* (CEC, 1997 p. 13). It is acknowledged that this option is not easy to accomplish. Therefore, it is proposed to start the EU wide regulatory framework for levies on pesticides with an allocation of the revenues to the sector and to use a part of these revenues for additional research on adequate regulations in the agricultural sector of the different Member States to refund the revenues to.

6.7 The contours of an EU wide regulatory framework for levies on pesticides

How does the contours of the EU wide regulatory framework for levies on pesticides looks like? In the preceding sections the following proposals have been put forward.

- First, it is proposed to define the framework to all (registered) pesticides used in the agricultural sector of the European Union. Potentially, this definition will produce the most beneficial effects to the environment.
- Second, it is proposed to put the EU wide levy on the value of the pesticides, alike the current system in Denmark. In the framework each Member State should be free to choose the retail price or the wholesale price as the exact charge basis of the levy. For

example, if farmers buy their pesticides mostly from the retailers, the levy should preferably be revealed in the retail price.

- Third, the charge rate system of the EU wide regulatory framework consists of minimum rates that are, preferably, differentiated towards the environmental hazards of the pesticides. If such a differentiation is not feasible, it is proposed to differentiate the levy towards the various types of pesticides. With respect to the charge rate, a levy of 20% is regarded plausible given the high efficiency of using the pesticides in the agricultural sector of the European Union, and given the outcomes of the pesticide chains in chapter 5.
- Fourth, industry should be used to collect and pass on the revenues of the EU wide levy. At this level the number of collection points is very limited, thereby simplifying the implementation and enforcement of the levy. All other imposition points - i.e., the farmers involved, the retailers, the wholesalers - are inferior to the industry.
- Finally, it is proposed to reimburse the revenues of the EU wide levy to the farmers involved and to use the revenues for (fiscal) regulations in the agricultural sector which further stimulate farmers to change their behaviour in a more environmental-friendly way. It is acknowledged that this option is not easy to accomplish.

Table 6.8 provides an overview of the proposed decisions on the five consequential elements of a European Union wide regulatory framework for environmental levies on pesticides, together with the scores on the criteria set out in section 6.1.

Table 6.8 An overview of the decisions on the consequential elements of an EU wide framework on pesticides

	Env. effect.	**Ec. efficient**	**Easy to acc.**	**Acceptable**
products involved • all pesticides used in the agricultural sector	✓ *(most)*	✓	✓	✓
charge base • value of the pesticides	✓	✓ *(more)*	✓	✓
charge rate system • minimum rates (differentiated)	✓ *(more)*	✓ *(more)*	✓	✓ *(more)*
imposition points • industry	-	✓ *(most)*	✓ *(most)*	✓
allocation of revenues • farmers involved (rewarding base)	✓	✓	✓ *(less)*	✓

Source: EIM

7 Conclusions

7.1 Introduction

This final chapter of the report is divided into four sections. In section 7.2 three essential elements of the study are described: i.e., the background of the study, the key objective of the study and the approach which was used to answer the research questions. In section 7.3 the most important conclusions that originate from the various chapters are reported. Together these sections form a brief summary of the issues discussed in this study. In section 7.4 general conclusions on the topic of an EU wide levy on pesticides will be drawn.

7.2 Background, objective and approach of the study

Background of the study

Whereas it is generally acknowledged that the use of pesticides[18] has large benefits to farmers, the present use of pesticides in agriculture also causes negative environmental (and health-related) effects to society. For example, during and after application of pesticides a substantial amount of it could end up in soil, ground- and surface water or air. These negative effects demands for an effective policy. Such policies have been initiated, both at the level of the individual Member States of the European Union and at the level of the European Union itself.

At the level of the European Union, at present, Council Directive 91/414/EEC concerning the placing of plant protection products on the internal market is probably the most prominent regulation. Whereas administrating this Council Directive will decrease the number of active ingredients on the internal market, full implementation is expected to take quite some time. Given this implementation problem, and the fact that administrating Council Directive 91/414/EEC will mainly ensure specified safety standards for pesticides without affecting the quantities used, there seems a need to broaden current European Union policy activities on pesticides.

In this regard, DG-XI has initiated a long-term project in co-operation with the Dutch Ministry of Housing, Spatial Planning and Environment, aimed at developing and evaluating new instruments and strategies for an additional EU pesticides policy, defined as additional to the present EU legislation, in particular Council Directive 91/414/EEC. This long-term project consists of two phases. The first phase was concluded in 1994, while the second phase was concluded in 1998. A total of eight studies have been published during

[18] This study deals with the plant protection products which are covered by Council Directive 91/414/EEC. These products are mainly used in agriculture and usually referred to as pesticides. Yet, in EU legislation pesticides are divided into plant protection products and biocides. Hence, when the word 'pesticides' is used in this report, it should be recognized that the plant protection products are meant as covered by Council Directive 91/414/EEC.

these two periods. In some of these studies, a levy on pesticides was regarded potentially effective in reducing the use of harmful pesticides in the European Union (see Oskam et al. 1997). However, a comprehensive evaluation of the economic and environmental effects of such a levy was not one of the key objectives of the long-term project.

In acknowledging the potential effectiveness of a levy to reduce the use of harmful pesticides in the European Union, DG XI initiated in 1997 a separate project to investigate the pro's and contra's of such a levy, and to define the contours of an EU wide regulatory framework for the taxation of pesticides. Note that an EU wide levy on pesticides would be in line with the 5^{th} *Environmental Action Program* (FEAP) which proposes to broaden the range of policy instruments from direct regulation towards economic instruments.

Objective of the study and research questions

As there is little experience in the Member States of the European Union with respect to a levy on pesticides it seems justified to represent the evaluation of such a levy as a kind of 'grey box': both with respect to its economic and environmental effects and with respect to defining a best working EU wide regulatory framework. As a consequence, the key objective of this study was *to enlighten this grey box*.

It should be recognised that such a process of enlightenment is warranted, given the implementation problem of Council Directive 91/414/EEC, the necessary environmental improvements in the European Union to reach the ambitious goals set out in FEAP, and the need to harmonise the internal market on this subject: i.e. in case a levy on pesticides would be defined by the Commission, the basic elements of this levy should hold for all Member States to avoid discrimination.

The following research questions were derived from the above-stated objective of this study.

1. In what respect is the experience presently available in the Member States on the use of pesticides useful for developing an EU wide regulatory framework for levies on pesticides?
2. What would constitute the ideal EU wide levy on pesticides?
3. Are there potential bottlenecks, if any, which could hinder the introduction of such a levy on pesticides?
4. What are the main economic and environmental effects of an EU wide levy on pesticides?
5. What would constitute the ideal EU wide regulatory framework for levies on pesticides?

Approach of the study

The approach which has been followed to answer the above-stated research questions consists of four major elements.

- Desk-research and expert interviews on the use of pesticides in the Member States of the European Union, on the effectiveness of a levy on pesticides, on ways to define a EU wide regulatory framework, etceteras.
- Building an economic model to analyse the main economic effects of an EU wide levy on pesticides. These effects relate to the change in using the pesticides, the change in pesticide costs at thefarm, the change in gross margin per farmer, and the expected revenues of the imposed levy.
- Developing a classification scheme of pesticides on the basis of their negative effects to the aquatic environment. In fact, seven classes have been distinguished. The most hazardous pesticides are those pesticides which are very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment (class I), whereas the 'least' hazardous pesticides are those pesticides which are harmful to aquatic organisms (class VII).
- Using so-called pesticide chains to come up with thorough estimates of the economic and environmental effects of a levy on pesticides. A pesticide chain consists of a certain type of pesticide, a certain crop in which the pesticide is used and a certain region in the European Union. An example of a pesticide chain is *fungicides in cucumbers in England and Wales.* By using this concept it was expected that, on the one hand, enough detailed information on the types of pesticide used, their environmental hazards, prices, and alternatives can be collected in order to gain reliable outcomes, while, on the other hand, it was expected that the outcomes are broad enough to design on an EU wide regulatory framework for levies on pesticides.

7.3 Conclusions from the various chapters

Below, the most important conclusions that originate from the various chapters of this study are reported. The relevant chapters are mentioned between brackets.

1. At present, there is little experience available in the Member States of the European Union which is useful for evaluating the economic and environmental effects of an EU wide levy on pesticides and for designing a best working EU wide regulatory framework. *(Chapter 3)*
2. Although a levy on pesticides is judged effective and useful, compared to other policy instruments, such as arrangements and regulations to reduce the use of harmful pesticides in the European Union, many scientists and policy makers involved believes that speeding up the review of Council Directive 91/414/EEC is the most effective policy instrument at the moment. (*Chapter 3*)

3. The ideal EU wide levy on pesticides consists of five essential features: it discriminates effectively among the various pesticides, it is set at the correct rate, it has an efficient collection and effective reimbursement system, it is fraud-proof and it provides a permanent incentive to the farmers. (*Chapter 3*)

4. The first two conditions of the ideal EU wide levy are confronted with major obstacles: on the one hand, because there is inadequate information on the (long-term) negative environmental effects of the pesticides, on the other hand, because it is difficult to set the EU wide levy at the correct rate. The other three-conditions of the ideal EU wide levy, however, pose no major obstacles:(*Chapter 3*)

5. The review of fifteen European studies shows that the demand of pesticides at the farms is so-called *relatively inelastic*: i.e., an overall price elasticity of demand for pesticides was computed ranging from - 0.2 to - 0.5. The price elasticity of demand for herbicides, fungicides and insecticides are, however, more elastic. For herbicides it lies between - 0.7 to - 0.9, for fungicides between - 0.4 to - 0.8, and for insecticides between - 0.3 to - 0.8. (*Chapter 4*)

6. On the basis of the nine pesticide chains evaluated it was concluded that an EU wide levy on pesticides of 20% will have a substantial impact on the use of pesticides at the farms.[19] An average decrease was computed of 14% for scenario 1 (one levy of 20% for all pesticides) and 18% of scenario 2 (a low levy of 10% for the least hazardous pesticides, a high levy of 40% for the most hazardous pesticides and a levy of 20% for all other pesticides). (*Chapter 5*).

7. The evaluations of the pesticide chains showed that the economic effects of a levy on pesticides of 20% are limited. An average increase of the total costs at the farms was computed of 0.1% for scenario 1 and 0.02% of scenario 2. Also the reductions in gross margin per farmer are also relatively small: € -143 versus € -155. (It should be noted that these income reductions were calculated without a reimbursement of the revenues. By using an effective re-allocation of the revenues the reported decreases in gross margin should be reduced.) *(Chapter 5)*

8. An explanation of the large differences between the environmental and economic effects of a levy on pesticides of 20% relates to the relatively high efficiency in using pesticides in agriculture. Due to this high efficiency - i.e., the estimated cost-shares in the pesticides used in the nine pesticide chains lie between 2% and 6% - the economic effects of a EU wide levy will be largely neutralised. *(Chapter 5)*

[19] It should be recognized that the outcomes of the nine pesticides chains depend heavily on the assumptions stated in section 5.2. Most probably, other levy scenario's, other price elasticity's of demand and other assumptions on the extent of substitution or complementary between the pesticides will result in other values.

9. On the basis of the outcomes of the nine pesticide chains it cannot be concluded that the results can be simply generalised to some higher level of aggregation. (*Chapter 5)*

10. As the contemporary information on the effects of a levy on pesticides is inadequate, it was not possible to present a blueprint for a best working EU wide regulatory framework for levies on pesticides. Instead a charcoal sketch of such a framework, including propositions for five major consequential elements, has been put forward. *(Chapter 6)*

11. With respect to the charge base system of the EU wide regulatory framework it is proposed to base the levy on the value of the pesticides (alike the system now in operation in Denmark). *(Chapter 6)*

12. With respect to the charge rate system of the EU wide regulatory framework it is proposed to set minimum rates that are, preferably, differentiated towards the environmental hazards of the pesticides. (If such a differentiation is not feasible, it is proposed to differentiate the levy towards the various types of pesticides.) *(Chapter 6)*

13. With respect to the reimbursement system of the EU wide regulatory framework it is proposed to reimburse the revenues of the levy to the farmers involved and preferable use them for (fiscal) regulations in the agricultural sector which further stimulate farmers to change their behaviour in a more environmental-friendly way.

7.4 General conclusions

It is recalled here that the key objective of this study was *to enlighten the grey box of an EU wide levy on pesticides*. The first general conclusion of this study is that this objective has been achieved only partially. For example, during the course of the research it became clear that for important topics, such as establishing an undisputed classification of the pesticides on their negative effects to the environment and setting the levy at the correct rate, there is still work to be done. This also holds for the assumptions which had to be made on the extent of substitution and complementary between the various pesticides in a pesticide chain.

A second general conclusion of this study is that introducing an EU wide levy on pesticides will be both effective and useful. *It will be effective* insofar as all (registered) pesticides used in the agricultural sectors of the EU Member States fall under the levy. Moreover, it will be effective insofar as the levy is based on the value of the pesticides.[20] It will be effective insofar as the EU wide levy aims to differentiate between the pesticides involved, preferably on the basis of their negative effects to the environment. Finally, the levy will be effective because it creates an automatic incentive for the farmers to use their pesticides more efficiently. *It will be useful* because an EU wide levy on pesticides forms an excellent addition to Council Directive 91/414/EEC. Moreover, it will be useful, be-

[20] In this regard, it is assumed that administrating Council Directive 91/414/EEC guarantees the removal of the older, cheaper and more hazardous pesticides from the market.

cause an EU wide levy on pesticides will further stimulate industry to innovate towards more environmental-friendly pesticides. Finally, it will be useful, because Member States' arguments on possible 'leakage's' at the borders and harming domestic farmers and industry will become trivial if the levy is set at the level of the European Union.

The third general conclusion relates to the EU wide regulatory framework for levies on pesticides. Despite the above positive characteristics of an EU wide levy on pesticides it should be noted that some important elements of the regulatory framework for levies on pesticides cannot be resolved within the scope of this study.

For example, it is unclear at the moment what the exact rate of the EU wide levy on pesticides should be and how it could be differentiated adequately. Whereas the proposal for differentiated minimum rates at the EU level still holds, it is argued that the exact minima (alike the regulatory framework on energy products) cannot be determined on the basis of current experiences in the European Union. In chapter 5 a levy of 20% was used for illustrative reasons. In section 6.4 such a rate has been justified on the basis of the relative low pesticides costs as percentage of the total yield. Yet, it is acknowledged that this argumentation is too brittle to actually base on specific minimum rates of the various levies.

Related to this topic is the extent of differentiation of the EU wide levy on pesticides. In chapter 4 a classification was introduced based on the negative effects of the pesticides to the aquatic environment. Albeit debatable, this classification was used in chapter 5 to base a levy system on. In essence, it was found that a differentiated levy system performed better than a undifferentiated levy system. Consequently, the ideal EU wide regulatory framework for levies on pesticides should base their classification system on the environmental hazards of the pesticides. Yet, much more research on this topic is required before an undisputed classification system can be established.

Also the precise level of detail of the EU wide regulatory framework on pesticides warrants further investigation. For example, in chapter 2 it was concluded that an EU wide regulatory framework for levies on pesticides should take into account the countries' specific agronomic circumstances in order to be acceptable. Questions which should be answered in this regard are: 'To what extent should the Commission define the exact charge base of the levy'?, 'To what extent should the Commission define the various differentiated levies on pesticides;?, or 'To what extent should the Commission define the way the revenues should be reimbursed to the agricultural sector'? Although these questions fall outside the scope of this study, the issue did come up in defining the charge rate system (section 6.4), the charge base system (section 6.3) and the reimbursement system (section 6. 6). More research on this topic is needed in order to provide conclusive answers.

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Annex I: Searching the relevant information

The methodology used to search the relevant information on the selected pesticide chains within the Member States of the European Union, can be divided into two approaches:

1. Search for databases and literature.

2. Personal contacts with experts on pesticides.

Ad 1 Search for databases and literature
By both the HASKONING Information Centre and the HASKONING Documentation Centre on Environmental Legislation extensive searches were performed to gather substance-specific information on the volumes and characteristics of pesticides, type and size of business, alternative methods etceteras. The most important information sources consulted were:

- FADN (Farm Accounting Data Network), via LEI-DLO;
- Eurostat;
- Central Statistics Bureau of the Netherlands (CBS);
- SwetScan;
- FAO Statistical Data 1990-1998;
- Pesticides Trust;
- Pesticide Action Network (PAN);
- International Substances Information System (ISIS/RISKLINE);
- Agrow's West European Fact Files;
- Library of the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM);
- Library of the Dutch Ministry of Agriculture, Nature and Fisheries (LNV);
- Library of the National Institute of Public Health and the Environment (RIVM);
- Library of the Wageningen Agricultural University (Mansholt Institute), via Agralin;
- PES-A studies:
- Handboek Bestrijdingsmiddelen, 1995 (Van Rijn, Van Straalen and Willems) (in Dutch);
- Gewasbeschermingsgids, 1995 (IKC & PD) (in Dutch).
- The Pesticide Manual, 1991 (Wothing & Hance, eds);
- European Council Directives 91/414/EEC, 93/21/EEC.

In general it can be concluded that only few data on the volumes and prices are available for individual pesticides in the Member States of the European Union. For the Dutch situation, however, useful data on pesticide use in specific crops have been found. The international data on pesticides that were found did not refer to individual pesticides or specific crops but to categories of pesticides (fungicides, insecticides) and general applications (cultivation under glass, arable agriculture). Such data are not suitable for the pesticide chains. Therefore the second approach - contacting experts on pesticides within the selected Member States - was used to complete the information needed.

Ad 2 Personal contacts with experts on pesticides
Several contacts were made with experts to collect the specific information on the selected pesticide chains. Those contacts were made by telephone, telefax and e-mail:

- Ministry of Agriculture, Fisheries and Food (MAFF, United Kingdom);
- Pesticides Safety Directorate (executive agency of MAFF, United Kingdom);
- Pesticides Usage Survey Group (executive agency of MAFF, United Kingdom);
- Posford Duvivier Ltd, Peterborough (United Kingdom);
- Alatec/HASKONING S.A., Madrid (Spain);
- Ministerio de Obras Publícitas, Transportes Y Medio Ambiente (Spain);
- Generalitat Valencia, Consellería D'agricultura, Pesca Y Alimentación (Spain);
- Ministerio de Agricultura Pesca Y Alimentación - Madrid (Spain);
- Ministerio de Agricultura Pesca Y Alimentación - Sevilla (Spain);
- Ministerio de Agricultura Pesca Y Alimentación - Almería (Spain);
- Swedish Environmental Protection Agency (Sweden);
- Miljödepartementet (Sweden);
- Swedish Board of Agriculture (Sweden);
- Ministère de l'Environnement, Direction de l'Eau (France);
- Ministère de l'Agriculture (France);
- Several wholesalers of pesticides (the Netherlands);
- DHV Consultants (the Netherlands);
- Wageningen Agricultural University (the Netherlands);
- Agricultural Economics Research Institute (LEI-DLO) (the Netherlands);
- Dutch Ministry of Agriculture, Nature and Fisheries (LNV) (the Netherlands).

Due to the precarious character of the study - analysing the possibilities of an EU wide levy on pesticides - it was decided not to contact the international and national trade organisations of pesticides manufacturing and formulating industry. Instead, all relevant responsible authorities in the selected Member States were consulted.

It appeared that the information needs for the selected pesticide chains were extremely hard to collect.

Annex II: Information sheets of the pesticide chains

Pesticide chain I : Fungicides in lettuce in England and Wales

Identification
Crop: Lettuce
Function pesticide: fungicide; protection against mildew
Important chemical means;
- Propamocarb-hydrochloride (by killing fungi)
- Fosetyl-aluminium (stimulation of plants' natural resistance)
- Tolclofos-methyl
- Thiram (blockade of metabolism in fungi by inhibiting certain enzymes in citric acid cycle)

Country : England/Wales

Volume applied per year (ref.: Pesticide Usage Survey, MAFF)
- Propamocarb-hydrochloride: 7.84 ton (active ingredient)
- Fosetyl-aluminium: 3.77 ton (active ingredient)
- Tolclofos-methyl: 3.04 ton (active ingredient)
- Thiram: 1.60 ton (active ingredient)

Costs (costs pesticide as a percentage of the total yield)
About 2% (estimated on the basis of the total of fungicides mentioned in LEI-DLO, 1994)

Prices per kilogram active ingredients
- Propamocarb-hydrochloride: 75 Euro
- Fosetyl-aluminium: 35 Euro
- Tolclofos-methyl: 70 Euro
- Thiram: 10 Euro

Type of businesses
Average size of farm: 4.1 ha (ref. Pesticide Usage Survey, MAFF)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)
- Propamocarb-hydrochloride: Harmful to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category III*
- Fosetyl-aluminium: Harmful to aquatic organisms: *category VII*
- Tolclofos-methyl: Toxic to aquatic organisms: *category VI*
- Thiram: Very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category I* (only tested in pure water without micro-organisms)

Alternatives (ref. Pesticide Usage Survey, MAFF)
None

Pesticide chain 2 : Fungicides in green peppers in Almeria

Identification
Crop: Green peppers
Function pesticide: fungicide; protection against mildew
Important chemical means;
- Ethirimol
- Triflumizole
- Pyrifenox
- Triadimenol
Country : Almeria (Spain)

Volume applied per year
- Ethirimol: 7,700 l/year
- Triflumizole: 14,000 l/year
- Pyrifenox: 11,000 l/year
- Triadimenol: 4,500 l/year

Costs (costs pesticide as a percentage of the total yield)
About 322 million Pesetas for control of mildew in green peppers in Almeria; i.e. about 2 million Euro (1996; estimated by Consejeria d'Agricultura y Pesca, Direction General de la Produccion Agraria, Sevilla)

Prices per kilogram active ingredients
- Ethirimol: 7 Euro
- Triflumizole: 16 Euro
- Pyrifenox: 16 Euro
- Triadimenol: 18 Euro

Type of businesses
Total area of green peppers in Almeria in 1996: 7,700 ha. (ref. Consejeria d'Agricultura y Pesca, Direction General de la Produccion Agraria, Sevilla)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)
- Ethirimol: Harmful to aquatic organisms: *category VII*
- Triflumizole: Very toxic to aquatic organisms: *category V*
- Pyrifenox: Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category II*
- Triadimenol: Harmful to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category III*

Alternatives (ref. Consejeria d'Agricultura y Pesca, Direction General de la Produccion Agraria, Sevilla)
None

Pesticide chain 3: Insecticides in cucumbers in England and Wales

Identification

Crop: Cucumbers

Function pesticide: insecticide; protection of crop by killing the insects

Important chemical means;

- Nicotine (inhibition of neurotransmitter transport in nerve system)
- Dichlorvos (inhibition of neurotransmitter transport in nerve system)
- Fenbutatin oxide (inhibition of neurotransmitter transport in nerve system)
- Propoxur (inhibition of neurotransmitter transport in nerve system)

Country : England/Wales

Volume applied per year (ref.: Pesticide Usage Survey, MAFF)

- Nicotine: 0.12 ton (active ingredient)
- Dichlorvos: 0.09 ton (active ingredient)
- Fenbutatin: 0.07 ton (active ingredient)
- Propoxur: 0.06 ton (active ingredient)

Costs (costs pesticide as a percentage of the total yield)

About 2% (estimated on the basis of the total of insecticides mentioned in LEI-DLO, 1994)

Prices per kilogram active ingredients

- Nicotine: 45 Euro
- Dichlorvos: 45 Euro
- Fenbutatin: 230 Euro
- Propoxur: 180 Euro

Type of businesses

Average size of farm: 3 ha (ref. Pesticide Usage Survey, MAFF)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)

- Nicotine: Very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category I*
- Dichlorvos: Very toxic to aquatic organisms: *category V*
- Fenbutatin oxide: Very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category I*
- Propoxur: Toxic to aquatic organisms: *category VI*

Alternatives (ref. Pesticide Usage Survey, MAFF)

Potato starch, *Anagrus spp.,Therodiplosis persicae,Diglyphus isaea, Amblyseius sp.*

Pesticide chain 4: Insecticides in cucumbers in the Netherlands

Identification

Crop: Cucumbers

Function pesticide: insecticide; protection of crop by killing the insects

Important chemical means:

- Dichlorvos (inhibition of neurotransmitter transport in nerve systems)
- Methiocarb (inhibition of neurotransmitter transport in nerve systems)
- Methomyl (inhibition of neurotransmitter transport in nerve systems)

Country: The Netherlands (Westland)

Volume applied per year (base year 1995, CBS, 1997)

- Dichlorvos: 2.54 ton (active ingredient) (3.1 kg/ha)
- Methiocarb: 1.41 ton (active ingredient) (1.7 kg/ha)
- Methomyl: 1.0 ton (active ingredient) (1.2 kg/ha)

Three a.i.: about 90% of total insecticides applied on cucumber in The Netherlands.

Costs (costs pesticide as percentage of the total yield)

2% (estimated on the basis of the total of insecticides mentioned in LEI-DLO, 1994)

Price per kilogram of active ingredients

- Dichlorvos: 45 Euro
- Methiocarb: 120 Euro
- Methomyl: 90 Euro

Type of business

Average size of farm: 3.9 ha (LEI-DLO, 1994)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)

- Dichlorvos: Very toxic to aquatic organisms: *category V*
- Methiocarb: Very toxic to aquatic organisms: *category V*
- Methomyl: Very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category I* (i.e. worst case scenario because actually few data on biodegradation in water are available; only data about pure water: results vary from good biodegradability to persistency).

Alternatives

- Biological crop protection (CBS, 1997)
- 5 predators are used against 4 frequently occurring insect plagues
- most widely used (about 90% of area) is mite *Amblyseius cucumeris* against *Thrips tabaci* or *Frankliniella occidentalis*.
- other predator-insect plagues combinations are only marginally used; however the importance of biological crop protection in specialist horticulture in The Netherlands is increasing.
- The application of the mite *Amblyseius cucumeris* (product "Thripex-plus") or insects of the *Reduviidae* family as preventive alternatives to chemical means costs about 3-10 ECU/100 m^2).

Pesticide chain 5: Fungicide in potatoes in Sweden

Identification

Crop: Potatoes

Function pesticide: fungicide: protection against *Phytophthora infestans*, causing potato disease

Important chemical means;

- Fluazinam (inhibition of cell division in fungi)
- Mancozeb (blockade of metabolism in fungi by inhibiting certain enzymes in citric acid cycle)

Country: Sweden

Volume applied per year (ref. National Chemical Inspectorate 1996)

- Fluazinam: 25.5 ton (active ingredient)
- Mancozeb: 39.2 ton (active ingredient)

Mancozeb mostly in combination with propamocarb and metalaxyl. Only used if necessary or if fluazinam can not be applied because of certain weather conditions.

Costs (costs pesticide as a percentage of the total yield)

2% (estimated on the basis of dose and price of formulation, by Swedish Board of Agriculture)

Price per kilogram (ref. Swedish Board of Agriculture):

- Fluazinam: 120 Euro
- Mancozeb: 30 Euro

Type of businesses

Average size of farm: 31 ha (estimated on the basis of acreage of arable land and number of farms; ref. the National Statistics Office of Sweden 1996)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)

Fluazinam: Very toxic to aquatic organisms: *category V*

Mancozeb: Toxic to aquatic organisms: *category VI*

Alternatives (ref. Swedish Board of Agriculture)

Use of uninfected seeds, buying special seeds such as uninfected seeds will be more expensive for the farmer but will at the same time save the expenditure for chemical pesticides.

Pesticide chain 6: Fungicides in potatoes in the Netherlands

Identification

Culture: Potatoes (agriculture);
Function pesticide: fungicide; protection against *Phytophthora infestans*, causing potato disease;
Important chemical means;

- Triphenyltinacetate (is absorbed by fungi. Inhibition of important physiological processes, causing death of fungi)
- Mancozeb (blockade of metabolism in fungi by inhibiting certain enzymes in citric acid cycle)
- Maneb (blockade of metabolism in fungi by inhibiting certain enzymes in citric acid cycle)
- Fluazinam (inhibition of cell division in fungi)

Country: The Netherlands

Volume applied per year (ref. CBS, 1995)

- Triphenyltinacetate: 126 ton (active ingredient)
- Mancozeb: 511 ton (active ingredient)
- Maneb: 557 ton (active ingredient)
- Fluazinam: 115 ton (active ingredient)

Costs (costs pesticide as a percentage of the total yield)

< 6% (estimated on the basis of the total of fungicides mentioned in LEI-DLO, 1994)

Price per kilogram:

- Triphenyltinacetate: 40 Euro
- Mancozeb: 7 Euro
- Maneb: 5 Euro
- Fluazinam: 90 Euro

Type of businesses

Average size of farm: 42 ha (ref.: LEI-DLO, 1994; common for agriculture);

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)

- Triphenyltinacetate: Very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category I*
- Mancozeb: Toxic to aquatic organisms: *category VI*
- Maneb: Very toxic to aquatic organisms: *category V*
- Fluazinam: Very toxic to aquatic organisms: *category V*

Alternatives

Preventive and biological counteraction: - Use of resistant crops: Approx. 50% (ref.: HASKONING & LEI-DLO, 1995); - Use of untainted seeds;
- Moderate use of nitrogen; In an early stage:
- Killing of the culture.

In general the use of resistant crops and/or untainted seeds will be more expensive for the farmer but will at the same time save the expenditure for chemical pesticides.

Pesticide chain 7: Herbicides in corn in the Netherlands

Identification

Crop: Corn
Function pesticide: herbicide: prevention from/destruction of weeds
Important chemical means:
- Atrazin (inhibition/disturbance of photosynthesis)
- Bentazon (inhibition/disturbance of photosynthesis)
- Pyridate (inhibition/disturbance of photosynthesis)
- Country: The Netherlands

Volume applied per year (based year 1995; CBS, 1997)
- Atrazin: 154.2 ton (active ingredient) (0.7 kg/ha)
- Bentazon: 99.9 ton (active ingredient) (0.5 kg/ha)
- Pyridate: 56.6 ton (active ingredient) (0.3 kg/ha)

Cost (costs pesticide as percentage of the total yield)
About 6% (estimated on the basis of the total of herbicides mentioned in LEI-DLO, 1994)

Price per kilogram
- Atrazin: 10 Euro
- Bentazon: 35 Euro
- Pyridate: 55 Euro

Type of business
Average size of farm: 42 ha (LEI-DLO, 1994)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)
- Atrazin: Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category II*
- Bentazon: Harmful to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category III* (i.e. worst case scenario because actually few data on biodegradation in water are available; bentazon is expected to biodegrade moderately, depending on the presence of specific micro-organisms)
- Pyridate: Harmful to aquatic organisms: *category VII*

Alternatives (CBS, 1997; PAGV & IKC, 1993; PAGV, 1995)
Mechanical weed control in corn is gaining importance. In 1995 mechanical weed control was applied at about 26% of the area used for corn cultivation. This was among others caused by stimulation of specialised equipment for this crop (weed harrow). A 100% mechanical treatment of the field, however, is often practically impossible to perform. This is caused by the fact that the timing of such activity is extremely important and that the farmer often hires some contract workers to do the job. The combination of an exact timing of mechanical weed control, a perfectly prepared crop field and the time schedule of contract workers appears to be impossible in practice.

Pesticide chain 8: Herbicides in winter barley in England and Wales

Identification
Culture: Winter barley
Function pesticide: herbicide: prevention from/destruction of weeds;
Important chemical means;
- Isoproturon (inhibition of transport electrons in cells; disturbance photosynthesis)
- Pendimethalin (inhibition of cell division in weeds)
- Mecoprop (uncontrolled plant growth because of auxin-like effect of mecoprop)
- Tri-allate (inhibition of cell division and extension in grow tips of plant)

Country: England/Wales

Volume applied per year (ref.: Pesticide Usage Survey, MAFF)
- Isoproturon: 719.20 ton (active ingredient)
- Pendimethalin: 125.39 ton (active ingredient)
- Mecoprop: 82.14 ton (active ingredient)
- Tri-allate: 67.74 ton (active ingredient)

Costs (costs pesticide as a percentage of the total yield)
5% (estimated on the basis of the total of herbicides mentioned in LEI-DLO, 1994)

Price per kilogram (ref. Pesticide Usage Survey, MAFF)
- Isoproturon: 12 Euro
- Pendimethalin: 28 Euro
- Mecoprop: 10 Euro
- Tri-allate: 17 Euro

Type of businesses
Average size of farm: 233 ha (ref.: Pesticide Usage Survey, MAFF)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)
- Isoproturon: Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category II*
- Pendimethalin: Very toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category I*
- Mecoprop: Harmful to aquatic organisms: *category VII*
- Tri-allate: Very toxic to aquatic organisms: *category V*

Alternatives (ref.: Pesticide Usage Survey, MAFF)
None

Pesticide chain 9: Fungicides in winter wheat in Sweden

Identification

Crop: Winter wheat

Function pesticide: fungicide: protection against leaf and ear diseases in winter wheat (a/o. rust, mildew)

Important chemical means;

- Fenpropimorf (is absorbed by fungi. Inhibition of steroid production, causing death of fungi)
- Propiconazol (is absorbed by fungi. Inhibition of important physiological processes, causing death of fungi)
- (Azoxystrobin: (approved on Swedish market only in 1997; application is expected to increase in following years))

Country: Sweden

Volume applied per year (ref. National Chemical Inspectorate 1996)

- Fenpropimorf: 54.0 ton (active ingredient)
- Propiconazol: 27.6 ton (active ingredient)

Fenpropimorf is mostly used in a mixture with propiconazol.

Costs (costs pesticide as a percentage of the total yield)

4% (estimated on the basis of dose and price of formulation, by Swedish Board of Agriculture)

Prices per kilogram (ref. Swedish Board of Agriculture):

- Fenpropimorf: 40 Euro
- Propiconazol: 240 Euro

Type of businesses

Average size of farm: 33 ha (estimated on base of acreage of arable land and number of farms; ref. the National Statistics Office of Sweden 1996)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)

- Fenpropimorf: Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category II* (i.e. worst case scenario because actually no data on biodegradation in water are available)
- Propiconazol: Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category II*

Alternatives (ref. Swedish Board of Agriculture)

Crop rotation, use of resistant strains, use of uninfected seeds

In general the use of resistant strains and/or uninfected seeds will be more expensive for the farmer but will at the same time save the expenditure for chemical pesticides. Adequate crop rotation does not have to result in increasing costs.

Pesticide chain 10: Herbicides in public pavements and roads in the Netherlands

Identification

Culture: -

Function pesticide: herbicide: prevention from/destruction of weeds

Important chemical means (from Galjaard et al, 1997);

- Diuron (inhibition of photosynthesis)
- Glyfosate (inhibition synthesis amino acids)
- Amitrol (inhibition carotene production and bud sprouting)
- Simazin (inhibition of transport electrons in cells; disturbance photosynthesis)

Country: The Netherlands

Volume use applied per year (base year 1995, from Galjaard et al, 1997)

- Diuron: 10.7 ton (active ingredient)
- Glyfosate: 9.8 ton (active ingredient)
- Amitrol: 1.8 ton (active ingredient)
- Simazin: 0.4 ton (active ingredient)

Costs (costs pesticide as a percentage of the total yield)

General costs of weed treatment on public pavements and roads in The Netherlands (Sluijsmans & Drijver, 1996)

Selective spraying by hand: 0.04 Euro / m^2

Full field spraying by hand: 0.08 Euro / m^2

Full field spraying by spraying boom: 0.03 Euro / m^2

Price

See total costs ad 3 (conventional) and ad 7 (alternatives)

Type of businesses

Weed control by governmental institutions (municipalities, water authorities etc.)

Classification (ref. ISIS/RISKLINE database; Van Rijn et al., 1995; Worthing, 1991)

- Diuron: Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category II*
- Glyfosate: Harmful to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category III*
- Amitrol: Toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category II* (i.e. worst case scenario because no good data on biodegradation in water are available; in pure water without micro-organisms poor degradation of amitrol)
- Simazin: Harmful to aquatic organisms and may cause long-term adverse effects in the aquatic environment: *category III* (results vary strongly)

Alternatives

Selective spraying by means of advanced equipment (with sensors): 2-5 cents/m^2 (=0.02 ECU/m^2); Mechanical removal (brushing): 10 cents/m^2 (=0.05 ECU/m^2); Physical removal (burning): 5 cents/m^2 (=0.02 ECU/m^2); Physical removal (steam): 5 cents/m^2 (=0.02 ECU/m^2).

Remarks: 2 and 3 are already widely applied whereas 1 and 4 are applied at a limited scale.