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# Agricultural Support Policies and Optimum Tax and Levy Scheme for Pesticide Use in Farm Production*

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**Abstract**

This paper documents the plethora of policy tools and measures undertaken throughout the European Union for controlling the excessive use of pesticides in agriculture. These tools and measures are classified into those that primarily target the farmer, the environment, the consumer, and the overall reduction of pesticide use. Emphasis is placed on tax- and levy-related tools and policies implemented within and outside the European Union. The paper provides a review of the literature dealing with the design of pesticide taxes, presents examples of countries which have implemented such measures, and considers other types of economic incentives used for controlling pesticide use. Examples of several national approaches and strategies towards pesticide risk reduction are also presented.

*JEL:* H23, Q18

*Keywords:* pesticide use, plant protection products, tax, levy, agricultural support policies.

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# 1. Introduction

The world population is currently estimated to be around 6.8 billion and is expected to reach 9.2 billion by the year 2050 (United Nations, 2007). This large population growth applies pressure to the agricultural sector to adjust its food production to meet the ever-increasing needs of the world. Throughout the years the need to boost the production of foodstuff has led the worldwide agricultural industry to the adoption of methods and techniques that aim at ensuring a high and increasing yield of crops. Ranking high among these methods is the use of pesticides.

A simple definition of pesticides would be "chemical substances used to protect plants against pathogens, insects, weeds and diseases". There are different categories of pesticides, each targeting a specific threat to plants. Some of the most popular categories of pesticides are herbicides (control of weeds), insecticides (control of insects), rodenticides (control of rodents), fungicides (control of fungi) and nematicides (control of nematodes). While pesticide applications undeniably aid agricultural production, their extensive use poses hazards to both human health and the environment. Given their necessity for farmers as an input to production it is, therefore, essential to establish methods and practices that level down the negative effects of pesticides and ensure their sustainable use. This paper documents the plethora of measures implemented throughout the European Union towards this goal.

The paper is organised as follows; the next section provides a brief discussion on various effects generated by the use of pesticides, as documented in the relevant literature. Section 3 highlights the key characteristics of the regulatory framework for the use of pesticides which applies to countries in the EU and the US. The subsequent four sections of the paper discuss measures used by EU member-states that target the protection of the farmer, the environment, the consumer, and overall pesticide use reduction. The eighth section presents a literature review on the subject of pesticide tax design and gives examples of economic instruments applied within and outside the EU to control the use of pesticides, with emphasis on tax-related measures. The ninth section provides examples of several national approaches and strategies towards pesticide risk reduction. Section 10 concludes the paper.

# 2. Benefits, costs and over-application of pesticides

This section provides a brief introduction to the positive and negative effects generated by the application of pesticides in modern agriculture, as documented in the literature, and summarises some of the reasons why farmers may overuse them. The aim here is not to provide an in-depth analysis of this topic but rather set the background for the discussion in sections that follow and highlight certain key points to help understanding better the issues pertaining to pesticide use.

Despite the fact that the emphasis in discussions is (and must be) often on the negative effects of pesticide use, one cannot disregard their many benefits for agricultural production. Pesticides are commonly known to reduce yield losses, improve the quality of agricultural foods, and control the possible spreading of diseases to humans and animals. As Cooper and Dobson (2007) point out, knowledge of the benefits from the use of pesticides can serve as a counterweight against their hazardous effects, thereby helping to acquire a more comprehensive and balanced view on the subject. The authors in their study document a number of benefits generated from pesticide use, and distinguish between those that are direct and easily identified (primary) and those that materialise in the longer term and are somewhat more difficult to observe (secondary). The first category includes improved crop yields and better crop quality, geographical containment of pests and reduced human disturbances and suffering. The second category includes less obvious benefits such as increased workforce productivity, increased farmers' revenues, food safety and security, and less migration towards urban areas.[1] Overall, a total of 26 primary and 31 secondary benefits are identified.

In general, one can find good reasons justifying the use of pesticides as inputs in the agricultural industry. Nevertheless, it is equally the case that severe side-effects to both humans and the environment are caused by these chemicals because they are used in large quantities and at an increasing pace. This has led some authors to go as far as to describe pesticides as poisons deliberately released in the environment to control pests, but in the end contaminate the soil and water and destroy the farmland ecosystems. Furthermore, farmers and agricultural workers directly exposed to them are poised, while pesticide residues that remain in the crops eventually enter the human food chain and cause numerous human health hazards (Carvalho, 2006; Travisi and Nijkamp, 2008; Mourato et al., 2000; Wilson and Tisdell, 2001).

Assessments of these negative externalities show that considerable costs are generated from pesticide use. According to Pretty et al. (2000) the total external cost for the UK agriculture in 1996 was equal to 2343 STG million, with a significant proportion of this harmful effect caused by pesticide use. In the US, approximately 500 million kilos of more than 600 different types of

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[1] On identifying the primary and secondary benefits of pesticide use, Cooper and Dobson (2007) differentiate them from the effects of pesticide use, the latter being the immediate outcomes, such as pest and disease control.

pesticides are used each year, generating a cost of $10 billion (Pimentel and Greiner, 1997; Pimentel, 2005). According to Pimentel (2005) the environmental and social costs from pesticide use in the US impact on public health and can result in poisoning and deaths of domestic animals and birds, contamination of ground and surface water and agricultural products, loss of beneficial natural parasites and predators, loss of crop and much more. Furthermore, it is argued that a vicious cycle can be caused by insect pests, weeds and plant pathogens developing resistance to these substances and chemical companies responding by developing new types of pesticides and farmers over-applying the ones currently in use (Carvalho, 2006; Pimentel, 2005).

A question arising when reviewing the hazards posed by pesticides to both human health and the environment is why the volume of pesticide applications often exceeds ordinary or recommended proportions. Clearly, agrochemicals help increase agricultural production and protect crops from numerous threats. Nevertheless, looking at the negative externalities associated with their use, it is plausible to ask: Why do farmers indulge to over-applying these substances? A number of possible explanations to the continuous overuse of pesticides are provided in a study by Wilson and Tisdell (2001). One such explanation is ignorance or lack of information on the topic. Farmers may not be fully educated on the issues of pesticide-related effects, or may not realise the difficulties involved in sustaining longer-term pesticide use. Even if they are informed about the longer term costs of their actions, farmers may be in a situation where they feel "forced" to use pesticides in production to avoid short-term economic losses. This farmer behaviour can also arise from the scarcity and/or high cost or unavailability of pesticide alternatives (Wilson, 1988). Box 1 provides a brief description of a few of the most popular non-chemical methods of plant protection.

Sheriff (2005) focuses on the general topic of the over-application of nutrients by farmers, and explores the reasons behind this phenomenon. One explanation he suggests is that farmers perceive the quantities of nutrients which agronomic advisors suggest as too conservative, and over-apply these substances thinking that this will increase output and maximise profits. In the case of pesticides the logic behind over-application is that under-application may not be effective, resulting in large losses due to a very bad crop. Instead of risking a total loss of their crop in the current year from pesticide underuse, the farmers choose to take the longer term risk of contamination from pesticide (Pearce and Koundouri; 2003). Another reason for pesticide overuse is the excessive cost of alternative forms of pest control and the policy of profit maximising farmers to select the cheapest substance that would do the job. Other reasons for over-applying pesticides may include pre-empting uncertain factors that can have a negative effect on agricultural production (i.e. the weather), and the underestimation of the benefits or the overestimation of the difficulties associated with the adoption of new (environmentally- and user-friendly) technologies and techniques.

**Box 1: Alternatives to Pesticides: A few examples**

Throughout the years a number of alternatives to pesticides have emerged. One that has been around for more than a decade is the development of Genetically Modified Organisms (GMOs). The term GMO generally refers to organisms whose genetic material has been altered in order to exhibit attributes that are not usually theirs. In the case of agriculture, GMOs are plants which have been genetically modified so that they would develop certain traits, such as resistance to pests and endurance to bad weather conditions, as well as increased nutritional value. Although this is a quite new and revolutionary approach, conventional plant improvement techniques have also been around for the past half a century (Pingali and Traxler, 2002).[2]

Another way to go is through organic agriculture. This form of agriculture avoids the use of agrochemicals and promotes the cultivation of food free of synthetic substances (Carvalho, 2006). This method relies on biological pest control, that is, control of pests through their natural enemies, such as predators, parasitoids and pathogens. However, this type of non-chemical plant protection has the downside of being more labour intensive, thus incorporating higher labour costs than conventional farming methods. As a result organic food products tend to be relatively expensive and not affordable by everyone.

Perhaps one of the most promising alternatives to the use of pesticides can be found in Integrated Pest Management (IPM) programs. IPM is defined by the United States Environmental Protection Agency as an environmentally sensitive pest management approach which combines information about the life cycles of pests and their interaction with the environment, with available pest control methods, to manage the damages caused by pests in the most economically efficient way, and with the least possible hazard to people and the environment.[3] Both developed as well as developing countries have undertaken the development of such programs, mostly due to concerns about the environmental and human health hazards associated with pesticide use (Cuyno et al., 2001). The use of the various IPM practices varies by the type of crop involved (Osteen and Livingston, 2006), and contrary to the application of expensive chemical pesticides, IPM offers the prospects of lower costs of production and higher profitability, while at the same time raising agricultural productivity and reducing health and environmental damages (Dasgupta et al., 2006; Cuyno et al., 2001).

Lastly, Best Management Practices (BMPs) are defined by the United States Environmental Protection Agency as schedules of activities, prohibitions of practices, maintenance procedures and other management practices that aim at preventing or reducing and controlling the pollution of surface or ground water from nutrients, pesticides and sediment. However the adoption rates of these practices by agricultural producers differ across crops, practices and geographical areas (Valentin et al., 2004).

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[2] Conventional plant breeding approaches involve crossing plants with different genetic backgrounds over several cycles in order to create new varieties with improved characteristics.

[3] More information available at: *http://www.epa.gov/opp00001/factsheets/ipm.htm*

In conclusion, despite their contribution to agricultural productivity, the damages caused by pesticides are not only severe but also multidimensional. Consequently, the use of different types of pesticides often implies a trade-off between more output and profits (mainly in the short-run) against different types of short- and long-run damages to the environment and/or human health (Mourato et al., 2000; Florax et al.; 2005, Newman et al., 2006). Therefore regulating the use of pesticides is of vital importance to individual countries, regions and the whole world. The remainder of this paper discusses the measures and policy tools used towards this goal, with emphasis on measures and policies in the European Union.

# 3. Regulation in the European Union and the US

## *3.1 Regulation in the European Union*

The protection of human health and the environment is a matter of utmost importance for the European Commission and thus, the EU seeks to ensure the proper marketing and use of pesticides in order to minimise their effects on humans, animals, and the environment. It is also among the EU goals to provide adequate and accurate information to both pesticide users and the general public about the various issues related to the use of pesticides and their residues in agricultural products, so as to raise awareness and encourage low-pesticide or pesticide-free cultivation techniques. In this context, Council Directive 91/414/EEC regulates the placing of plant protection products on the market. Specifically, the Directive regulates the evaluation and approval of active substances at EU level as well as the thereafter authorization of plant protection products containing these substances, at member-state level.

As regards the evaluation and authorisation of pesticides, Directive 91/414/EEC states that active substances cannot be used in plant protection products (PPPs) unless included in a list of substances authorised at EU level.[4] In 1993, an evaluation of active substances used within the EU was undertaken by the "European Community (EC) review program for existing active substances". This was a four-stage program aiming at ensuring that all pesticides used throughout the European Community meet modern safety standards.[5] The programme, which was completed in March 2009, generally involved a review process of all active substances used in PPPs within the EU, verifying whether or

[4] European Commission website: Plant Protection – Introduction: *http://ec.europa.eu/food/plant/protection/index_en.htm*

[5] United Kingdom's "Pesticides Safety Directorate (PSD)": *http://www.pesticides.gov.uk/approvals.asp?id=2317*

not they could be used safely for human health and the environment. At the completion of the programme, from a total of roughly 1000 substances, 26% were approved, 7% were removed from the market (they were identified as hazardous to human health and the environment) and 67% were eliminated from the review process and also removed from the market.[6]

In addition to monitoring the marketing of plant protection products, the European Union also seeks to ensure that the residues of pesticides that remain in all food products intended for consumption by humans do not exceed a certain maximum level known as Maximum Residue Level (MRL). The latter is defined by the European Commission (2008) as the highest level of a pesticide residue legally tolerated in or on a food or feed.

Until recently, four Council Directives regulated pesticide residues in food and feed in the EU (76/895/EEC, 86/362/EEC, 86/363/EEC and 90/642/EC), and residue legislation was a responsibility of both, member states and the Commission. In this setting, the rules that applied for the setting of MRLs throughout the EU were somewhat complex; that is, for some pesticides the MRLs would be set by the European Commission whereas for others they would be set by member-countries. Or, alternatively, for some pesticides the Commission could set MRLs which the member-states could thereafter increase. There were also cases of pesticides for which no MRLs were set. As a result, the MRLs that applied in the EU differed from one member-state to another. With 27 different lists of MRLs this setting could be very confusing for consumers, as well as traders and importers of pesticides (European Commission, 2008). To address this issue, as of September 2008, a new legislative framework on pesticide residues (Regulation (EC) No 396/2005 of the European Parliament and of the Council) came into effect in the EU. This Regulation promotes the harmonisation and simplification of pesticide MRLs, and is intended to ensure a higher level of consumer protection throughout the EU. Specifically, according to the European Commission, the new Regulation sees that MRLs go through a common EU assessment so as to ensure sufficient protection for all consumers, including the vulnerable classes, such as children and babies.[7]

The efforts to sustain the use of pesticides in the EU have also been amplified through the European Commission's adoption of a "Thematic Strategy on the Sustainable Use of Pesticides". This project was launched in 2002 and is still under development. It aims at complementing the existing legal framework, as one of seven strategies introduced by the European Community's Sixth

[6] European Commission website, Review Programme of existing pesticides:
*http://ec.europa.eu/food/plant/protection/evaluation/rev_prog_exist_pest_en.htm*

[7] European Commission website: Plant Protection-Pesticide Residues:
*http://ec.europa.eu/food/plant/protection/pesticides/index_en.htm*

Environmental Action Programme, covering the fields of Air, Waste Prevention and Recycling, Marine Environment, Soil, Pesticides, Natural Resources and Urban Environment.[8] The primary purpose of the pesticides thematic strategy is to fill the legislative gap regarding the use of pesticides, and also encourage the research and development of other, less harmful alternatives. As described earlier in this section the existing EU policies and regulations strongly address the issues of placing pesticides in the market and the pesticide residues in final consumption products. Within this context the actual use of pesticides in agricultural production is somehow overlooked. This has resulted in misuses (and overuses) of pesticides which have led in a non declining percentage of food and feed sample in which pesticide residues exceed MRLs, over the last ten years.[9] Therefore the main focus of the Thematic Strategy on the Sustainable Use of Pesticides is to identify a set of policy objectives and requirements that member-states will have to reach within the coming years, in order to ensure a more sustainable use of pesticides in agricultural production and, in a broader context, create a more coherent and consistent overall policy framework (Commission of the European Communities, 2006).

The primary objectives of the Thematic Strategy on the Sustainable Use of Pesticides include minimising the hazards and risks to health and the environment from the use of pesticides, improving controls on the use and distribution of pesticides, reducing the levels of harmful products, including through the application of the substitution principle (substituting dangerous substances with safer alternatives), encouraging the use of low-input or pesticide-free crop farming, and developing suitable indicators and providing valuable feed-back, so as to establish a transparent system for reporting and monitoring the progress made.[10]

Possible means to reach these objectives included in the EU's strategy are developing national plans for the reduction of risks, hazards and dependences on chemical control, protection of sensitive areas, general ban of aerial spraying, compulsory training of all pesticide users, imposition of penalties on users, introduction of special levy schemes on plant protection products, harmonisation of the value-added tax for pesticides, and more (Commission of the European Communities, 2002). Table 1 provides detailed information on this topic.

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[8] The Sixth Environment Action Programme of the European Community 2002-2012 – Thematic Strategies: *http://ec.europa.eu/environment/newprg/strategies_en.htm*

[9] European Commission website: Sustainable Use of Pesticides - A strategy to ensure safer use of pesticides: *http://ec.europa.eu/environment/ppps/strategy.htm* and Commission of the European Communities (2006).

[10] European Commission website: Sustainable Use of Pesticides – Objectives of the Thematic Strategy: *http://ec.europa.eu/environment/ppps/objectives.htm*, and Commission of the European Communities (2002).

Table 1: Thematic Strategy on the Sustainable Use of Pesticides: main objectives and possible solutions

| Objective | Possible Solutions |
|---|---|
| (1) Minimise the hazards and risks to health and the environment caused by pesticide use | - Establishment of national plans for reduction of hazards, risks and dependence on chemical control.<br>- Specific protection of sensitive areas.<br>- General ban of aerial spraying (with derogations under specific conditions).<br>- Improve knowledge on risks through monitoring of user health, data collection on incidents, collection and analysis of economic data on PPP use and alternatives.<br>- Technical improvements of application and protection equipment.<br>- Further research and development (for topics such as IPM techniques, improved insurance schemes against potential crop losses, less dangerous application methods, solutions to point source pollution issues etc.) |
| (2) Improve controls on the use and distribution of pesticides | - Statistics on production, import/export, and use (reporting by producers and distributors to national authoriities).<br>- Control of spraying equipment, packaging and waste.<br>- Reinforce ongoing efforts on collection of data on PPP use.<br>- Creation of a system for compulsory training, awareness raising, and certification of users |
| (3) Application of the substitution principle to reduce levels of harmful active substances. | - Quicker implementation of Directive 91/414/EEC and its amendments. |
| (4) Encourage low-input or pesticide-free crop farming | - Promotion of alternatives to chemical PPPs through Integrated Pest Management (IPM), organic farming.<br>- Examine the potential of applying genetical modification technology.<br>- Promotion Good Farming Practices<br>- Imposition of penalties on non-complying users.<br>- Special levies on PPPs.<br>- Harmonisation of VAT for PPPs. |
| (5) Establish a transparent system for reporting and monitoring progress made - Develop indicators. | - Report by member-states on risk reduction programs.<br>- Development of suitable monitoring indicators and definition of quantitative targets.<br>- Contribute to the OECD work on the development of harmonised indicators. |

Source: Commission of the European Communities (2002).

Safeguarding environmental quality is also among the EU's priorities. To protect the quality of water from pesticides, the EU Water Framework Directive provides an integrated framework for the assessment, monitoring and management of surface- and ground-water based on their ecological and chemical status. The directive requires that measures be taken to reduce or eliminate emissions, discharges and losses of dangerous substances, so as to protect surface waters. In the same context, the EU also seeks to ensure the protection of soil, polluted through the dispersal of pesticides into it, and run-offs during or after the cleaning of the application equipment, or through uncontrolled disposal of pesticides or the application equipment.[11]

In general, EU regulations may be viewed as a set of general guidelines that each member-state may adopt, adjust to its own individual needs and characteristics or use as a supplement to its national strategies. To this extent, regarding the case of pesticides (or plant protection products more generally), EU member-countries use a wide range of tools, at a national level to control the risks associated with pesticide use. This paper classifies these tools and measures into those which primarily target (a) the farmer, (b) the environment, (c) the consumer, and (d) the general reduction of the use of pesticides. The following sections discuss these topics.

## *3.2 Regulation in the US*

The organisation responsible for the regulation of pesticide use in the United States is the Environmental Protection Agency (EPA). The EPA regulates pesticide use under the authority of two federal statutes, The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA).[12]

The FIFRA is the U.S. federal law that provides the basis for the regulation, sale, distribution and use of pesticides in the U.S. It bestows EPA the authority to assess and register pesticides, and also to suspend or cancel the registration of a pesticide if new information shows that its subsequent use may cause unacceptable levels of risk. In general, all pesticides that are intended for distribution or sale in the U.S. must be registered with the EPA. For a pesticide to acquire a license it must be proven that its proper use will not generally cause "unreasonable adverse effects on the environment". The latter term is defined by FIFRA in two ways: (a) "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs

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[11] European Commission: Agriculture and Pesticides. Available at: *http://ec.europa.eu/agriculture/envir/index_en.htm#pesticides*

[12] EPA website. Pesticides: Laws and Regulations: *http://www.epa.gov/pesticides/regulating/laws.htm*

and benefits of the use of any pesticide", and (b) "a human dietary risk from residues that result from a use of pesticide in or on any food inconsistent with the standard under section 408 of the Federal Food, Drug and Cosmetic Act".

The registration procedure for a pesticide is performed after a period during which data are collected in order to determine its effectiveness for the intended use, appropriate dosage and hazards. After the registration of a pesticide is complete, a label is created to inform users of its proper use.[13] Based on the reviewing procedure (different categories of pesticides go through different review processes) the registration of a pesticide may take up to several years.

The FFDCA gives EPA the authority to set the maximum residue levels, or tolerances for pesticides used in foods intended for human or animal consumption. Foods in which residues of pesticides are found over the maximum allowed level are subject to seizure by the government. In addition, if a food product contains a pesticide for which there is no tolerance assigned, then that food will also be subject to seizure. To set a tolerance or maximum residue level for a pesticide EPA takes into account, among other things, its toxicity and the toxicity of its break-down products, aggregate exposure to the pesticide from foods and other sources of exposure, and any special risks that are posed to children or infants. A tolerance is considered safe if there is reasonable certainty that aggregate exposure to the pesticide residue will not result to any harm.[14]

Additional pesticide related US legislation include: (a) the Pesticide Registration Improvement Act (PRIA) which establishes pesticide registration service fees; (b) the Food Quality protection Act (FQPA) which amended FIFRA and FFDCA to set stricter safe standards for both old and new pesticides and to make uniform requirements with regards to processed and unprocessed foods; and (c) the Endangered Species Act (ESA) through which EPA must ensure that the pesticides it registers will not cause any harm to species identified as endangered or threatened by the U.S.[15]

## 4. Supporting the farmer

In addition to EU level measures, member-countries of the EU have established national policies, tools, and instruments for the purpose of managing

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[13] EPA website. Summary of the Federal Insecticide, Fungicide, and Rodenticide Act: *http://www.epa.gov/regulations/laws/fifra.html*

[14] EPA website. Summary of the Federal Food Drug, and Cosmetic Act: *http://www.epa.gov/lawsregs/laws/ffdca.html*

[15] EPA website, 'Pesticides: Laws and Regulations': *http://www.epa.gov/pesticides/regulating/laws.htm*

the use of plant protection products. This section discusses a number of such instruments focusing on the farmers applying pesticides mainly as professionals but also as amateurs.

## *4.1 Training*

All countries across the EU promote the training and education of farmers. This approach is essential in more than one ways; firstly, it aims at ensuring that farmers are fully aware of the consequences of over-application or, generally, misguided application of pesticides. Secondly, farmers become aware of alternatives to pesticides for plant protection and new cultivation techniques. Thirdly, and perhaps most importantly, training courses teach farmers to make careful selections with regard to inputs in their production process.

Of course, across EU member-countries there are different ways through which farmer training and education is carried out. Further to mandatory training courses, countries provide other tools as well, in order to raise the farmers' level of expertise in pesticide handling, along with their awareness about the risks surrounding their use. Several countries have promoted, in addition to their official laws, Codes of Good Agricultural Practice (for example Cyprus, Malta, the UK, Bulgaria, Slovenia, Germany, Romania)[16]. The latter typically include a set of formal guidelines for the proper use of pesticides by farmers, so as to ensure human and animal health, and environmental quality. These guidelines primarily seek to ensure that farmers apply the correct type of pesticide, to the correct type of crop, at the correct dosage, using the correct application procedure. The instructions also provide useful information regarding spraying, mixing of different types of pesticides, disposal of empty pesticide containers, necessary precautions to be taken prior and during the application of pesticides, and other instructions regarding their safe use. Consequently, the correct application of these codes, seeks to ensure farmer health and a high level of food quality, with no (or the least possible) pesticide residues.

An interesting example of such guidelines can be found in Finland, where farmer training received particular attention when the Balanced Crop Protection project took place between 2000 and 2006. During this time a team of scientists, advisors, and members of the agricultural industry worked together to produce a series of booklets that provided directions for balanced protection for 24 different types of crops and also one book addressing crop protection in ecological farming. These booklets provided useful information to farmers,

[16] Cyprus: Ministry of Agriculture, Malta: Ministry for Rural Affairs and the Environment, UK, Germany and Slovenia: OECD (2006), Bulgaria and Romania: Black Sea NGO Network (website).

covering issues such as selecting the right variety of crop, the right field, the right crop rotation, and the right crop protection method. Farmers were required to purchase the booklet covering the crops they grew and, as a result, their training was promoted substantially (Autio and Hynninen, 2007).

Several European countries, including Spain, Italy, France, Germany, Belgium, Denmark, the UK and Poland have, at times, established "demonstration farms" where farmers can observe various cultivation methods and practices and alternative ways through which they can protect their crops, without damaging the environment. Demonstration farms may differ from one country to another due to different climates, or the types of agricultural products each country produces. Nevertheless, the basic idea underlining their implementation is that demonstrating to farmers what they should do is generally more effective than simply instructing them.[17]

The internet has also proven to be an efficient way to channel knowledge and provide useful tools to pesticide users, in terms of both legislation and general information about the use of plant protection products. All member-states of the EU have at least one website providing this sort of information, and, in addition, a regularly updated register of authorised plant protection products and active substances. Public access to information is also strongly promoted throughout the EU.

Professional users of Plant Protection Products (PPPs) in the EU are generally required to possess a certificate of knowledge in order to purchase and use certain types of highly toxic substances. The procedures for obtaining such certificates may differ from one member-state to another, but the basic idea is the same; that is, in order to be allowed to use (at least certain types of very toxic) plant protection products, users first need to acquire a certain level of knowledge about the use and properties of these substances, so as to be fully aware of all their effects. It is generally the case that these certificates are only valid over a certain period. In the Netherlands, for example, certificates of professional users are reviewed every five years (OECD 2006). Similarly, in France and Finland, farmers must attend obligatory re-training every five years.[18]

### *4.2 Other farmer support measures*

Another form of farmer support comes through the creation of advice systems, information systems, decision support systems, discussion groups and

[17] Germany: OECD (2006), Spain, Italy, France, Germany, Belgium, Denmark, the UK and Poland: Balsari and Marucco (2008).

[18] Finland: Autio and Hynninen, 2007, France: Duclay and Casala, 2007.

any other form of additional guidance and consultancy to farmers, even after they have completed a training course and/or received a certificate. The UK, Denmark, Sweden and Germany, for example, have implemented such systems (OECD, 2006). Providing farmers with proper guidance is essential because it typically prevents them from breaking the rules. Information systems may also be useful in informing the agricultural sector about what equipment is available in the market. In France, for example, measures are taken so that the most efficient equipment receives wide publicity, and those working in the farming sector are well informed as to which equipment offers them the best protection (Duclay and Casala, 2007).

Policies targeting the education of farmers are complemented by policies seeking to ensure farmer safety. As discussed earlier, pesticide use creates risks to human health. On the farmer's side of things, the primary cause of these risks comes from direct exposure to the chemicals during their application. As an effect, possible problems to the health of farmers (or any user for that matter) may arise. To this extent it is mandatory in EU member-countries for all application equipment to be thoroughly tested prior to use and, also, to be regularly tested after certain periods of time.

The procedures followed for checking plant protection application equipment and the time between checks may vary from one country to another. In Germany, for example, the testing of spraying equipment is performed every two years (OECD, 2006). In France, minimum quality standards for new or second-hand spraying equipment sold have been imposed, and measures are taken to improve the quality of application equipment through regular inspections (Duclay and Casala, 2007). Similarly, in Slovenia and the Czech Republic application equipment intended for professional use is subject to obligatory assessment prior to being placed on sale, and is thereafter subject to frequent obligatory checks to verify its technical condition.[19] There are cases when, if spraying equipment does not meet certain standards, or if violations have occurred, corrective actions may take place, such as the imposition of fines (in Estonia, for example, fines up to €962 may be imposed), or the issuing of warnings or official Reports (as in Belgium). In Bulgaria, and Latvia tests may be performed without prior warning.[20] In Cyprus there is currently no law that regulates the testing of application equipment, but an EU directive is expected to be adopted in 2009, which will make it mandatory for spraying equipment to be tested every three years (Lyssandrides, 2008).

[19] Slovenia: OECD (2006), Czech Republic: European Commission, The Food and Veterinary Office, Country Profile of the Czech Republic (from website).

[20] European Commission, The Food and Veterinary Office, Country Profiles of Estonia, Belgium, Bulgaria and Latvia.

In general, all efforts focusing on farmer training and support in the EU have in common the goal of making farmers take into consideration the health and environmental aspects of pesticide applications, and therefore make careful decisions and avoid excessive and unnecessary use of plant protection products. Training courses and advice services are two very effective channels trough which alternative methods of crop protection, other than the chemical ones can be promoted. Thus, in cases where the application of chemical substances is necessary, applications are promoted subject to 'need-based' and 'minimum-necessary' principles.

Table 2 summarises the measures implemented in EU countries in order to make farmers use pesticides correctly.

**Table 2: Summary of tools and measures focusing on farmers**

- Farmer training and education
- Requirement for professional users to obtain certificate of knowledge in order to be allowed to use (at least certain) pesticides on a professional basis
- Review of certificates after certain time periods
- Publication of Codes of Good Agricultural Practice by national authorities
- Printed instructions on specific issues, and other forms of formal guidelines
- Demonstration farms
- Easy access to information (i.e. via the internet)
- Regularly updated registers of authorised pesticides and active ingredients
- Advice and information systems/consultancy
- Decision support systems
- Discussion groups
- Promotion of best technical (application and protection) equipment
- Mandatory checks of application equipment prior to being placed on the market, prior to use and also at frequent time periods
- Setting of quality standards for application equipment
- Imposition of fines in cases of non-compliance

# 5. Safeguarding the environment

Measures aiming at ensuring the protection of the environment and preserving its quality are also of high importance. Most of the aforementioned measures, while directly focusing on the farmer, have the long-term effect of also safeguarding the environment. In addition, there is a variety of additional measures that are used throughout the EU specifically for this purpose. One such measure is the identification of nature protected areas and, consequently, the enforcement of restrictions to the use of pesticides near these areas. These restrictions may include the setting of maximum limits with regards to the type, dosage amount, and methods of application of the pesticides used near these areas. Buffer zones may also be introduced as, for example, in Belgium (von Bol, 2007). The latter are zonal areas used to keep two or more areas in some distance from each other. Thus, buffer zones may be used to separate areas where pesticide applications take place from protected areas. Restrictions may also be imposed to cultivation near nature protected areas and the proximity of the application location near nature protected areas, as the Czech Republic (European Commission – The Food and Veterinary Office (FVO), Country Report of the Czech Republic, 2008). Aerial spraying near these areas is also forbidden. In fact, aerial spraying is generally considered as the least preferable pesticide application method in the EU.

Controls are also used to sustain the use of plant protection products near water resource areas or areas surrounding water-supply reservoirs, as water may be polluted via spray drifts, run-offs during or after the cleaning of the application equipment, or via uncontrolled disposals of residual pesticide solutions. As discussed earlier in this paper, the EU seeks to protect the quality of water with respect to pesticides and the role of the EU Water Framework Directive is to provide an integrated framework for assessment, monitoring and management of all surface waters and groundwater, based on their ecological and chemical status.[21] It should be noted, however, that EU regulations are viewed as supplementary to national measures, as each country designs its own (national or regional) action plans which suit specific needs associated with its topographic and climatic conditions. For example, Belgium has its own regulations restricting pesticide use near water catchment areas, and monitoring system for ground- and surface-water at a regional level (von Bol, 2007).

One of the most important factors leading to water contamination from PPPs is pollution originating from point sources (Balsari and Marucco, 2008). Studies have shown that point sources are responsible for more than 50% of water contamination from plant protection products (Kreuger, 1998; Maillet-Mazeray et al., 2004; Neal et al., 2006). The preparation of the mixtures, the filling of the spraying equipment, the management of the remaining mixture at the end of the application, and the cleaning of the equipment afterwards are among the major factors leading to point source pollution, due to the fact that

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[21] European Commission: Agriculture and Pesticides. Available at: *http://ec.europa.eu/agriculture/envir/index_en.htm#pesticides*

these activities tend to take place in the same area of the farm, usually near a water source. In addition, these activities may be carried out several times during the farming season, and, as a result, spills and accidental overflows, may lead to liquids containing pesticides to infiltrate groundwater or surface water (Balsari and Marucco, 2008).

In 2005, a large-scale, three-year European project aimed at reducing plant protection products point source contamination came into effect. The project, named Training the Operators to prevent Pollution from Point Sources (TOPPS), seeks to identify and disseminate best management practice guidelines at a large coordinated scale in Europe, with the intention of reducing plant protection product spills into groundwater and surface water.[22] A total of 15 European countries participate in the TOPPS project, grouped into four clusters: South (Italy, Portugal, Spain, south of France), Mid West (Belgium, Netherlands, Germany, north of France, UK), Nordic (Denmark, Sweden, Finland), and East (Poland, Hungary, Czech Republic, Slovakia).

Improper disposal of obsolete, expired or no longer authorised pesticides is a major issue in safeguarding the environment. In some cases, farmers maintain old storage facilities which contain obsolete or banned plant protection products. These pesticides are hazardous to both the environment and human health. It is important for countries to take initiatives (both at national and local level) and implement appropriate measures for the correct storage and disposal of these products. Such initiatives taken are already followed by several EU countries, especially East European countries facing severe problems from the accumulation of hazardous obsolete or banned plant protection products.

- In Bulgaria, local initiatives, with the support of the government and several private companies, constructed new storage facilities so that obsolete pesticides can be safely stored.[23]

- In Lithuania, the company SAVA plans to pack obsolete pesticides into 60 litre polyethylene or 200 litre metal containers which after being marked and labelled will be transported to Germany and incinerated by the company SAVA Gmbh & CO within 24 hours after delivery (European Commission - FVO: Country report of Lithuania, 2008).

- A similar initiative took place earlier in Romania, where regional cooperation led to the collection of a total of 2515 tons of obsolete pesticides in 218 cities, which was then repackaged and transported to Germany where it was

[22] TOPPS website: 'Objective': *http://www.topps-life.org/web/page.asp?cust=1&lng=en&m=1&s=1*

[23] HCH Pesticide Forum Report: *http://www.wecf.eu/english/articles/2005/06/hch_forum.php*

destroyed in an incinerating facility for hazardous waste (European Commission - FVO: Country report of Romania, 2007).

- In the Czech Republic, farmers can apply for compensation for disposal costs (European Commission - FVO: Country report of the Czech Republic, 2008).

- In Ireland, owners of obsolete pesticides are obliged to destroy them at their own expense (European Commission - FVO: Country report of Ireland, 2007). The destruction is carried out by licensed contractors.

- In contrast, Luxemburg has in place a procedure by which stocks of expired or no longer authorised plant protection products are collected free of charge by a State-funded company (European Commission - FVO: Country report of Luxemburg, 2008).

Table 3 summarises the various policies, measures and other practices used in EU member-countries specifically for safeguarding the environment from improper use of plant protection products.

**Table 3: Summary of tools and measures focusing on the environment**

- Identification of areas that must be protected and enforcement of restrictions to the use of pesticides near or inside these areas (for example setting of maximum limits with regards to the type of pesticide, dosage amount, and application method)
- Introduction of buffer zones
- Bans of aerial spraying
- Controls on the use of pesticides near water resource areas or areas surrounding water supply reservoirs
- National plans which suit country-specific needs and characteristics (topographic and climatic conditions)
- Monitoring of surface and groundwater contamination levels
- Actions and projects that target the prevention of point source pollution
- Initiatives towards the proper disposal of obsolete pesticides

# 6. Protecting the consumer

Plant protection products may pose a threat to consumer health, if residues of these substances remain in the final product intended for consumption. For this reason, each EU member-country makes one or more national authorities responsible for monitoring and controlling the presence of pesticide residues in food products of plant origin, such as fruit, vegetables, cereals, and processed products of plant origin including baby foods.[24] The procedures involved in residue monitoring usually require the authority responsible to examine samples from each category of foodstuffs and ensure that pesticide residues, if any, do not exceed the Maximum Residue Levels that apply for the specific product. The same authority is also required to prepare a monitoring plan specifying the products to be sampled, the number of samples to be taken, and the substances for which they will be tested. The sampling procedures tend to vary from one crop to another and are generally based on risk analysis and previous experience. Checks and inspections may take place at various levels such as at wholesale and retail level, at import, or even at the farm level.

When non-compliant samples are identified, various measures may come into effect.

- In Belgium, products suspected of non-compliance with the minimum pesticide residue requirement are seized so that they do not enter the market, and all non-compliant samples are assessed to see if they pose a risk to the consumer (European Commission - FVO: Country report of Belgium, 2007). Thereafter, actions are taken so that the violation is verified and its cause identified, and the producer or importer is placed under more strict controls.
- In the Czech Republic, additional sampling (outside the national programme) may occur in case of detected violations or consumer complaints, and in addition to precautionary measures, such as the withdrawal of the suspected products from the market, fines may be imposed (European Commission - FVO: Country report of the Czech Republic, 2008).
- In Greece, when non-compliance is detected, a dossier is sent to the head office (which can directly impose sanctions) and the public prosecutor. Violators are restricted from supplying the products until further testing is accomplished (European Commission - FVO: Country report of Greece, 2008).
- In Poland, depending on the nature of the violation of pesticide laws, follow-up measures may include prosecution, imposition of fines, referrals to a court of justice (when health risks are identified), withdrawals of the products from the market, or seizure and destruction of the products (European Commission - FVO: Country report of Poland, 2008).

[24] Frozen and dried food products may also be monitored. Detailed information about the national authorities responsible for monitoring pesticide residues in each member state is available on the European commission website, FVO Country Profiles section at: *http://ec.europa.eu/food/fvo/country_profiles_en.cfm*

In addition to monitoring residue levels in food products, several other measures exist for the protection of consumers from pesticide use, such as pesticide residue monitoring in drinking water. Some of these measures were mentioned earlier, in the discussion of how farmers should be encouraged to avoid water contamination with pesticides at point sources.

Consumers may also be at risk if the use of PPPs is carried out near certain locations, accessed by the general public, such as schools, parks, public places, domestic locations, and so on. Within this context, measures are taken by EU countries to ban or restrict the application of PPPs near these types of areas. It is also important for consumers to be informed about the risks related to the presence of chemical residues in the products they buy. Information campaigns are on the way in many EU countries to raise awareness, e.g. through the internet. Also, the labelling of agricultural products at selling point to ensure transparency about the agricultural practices (e.g. organic) by which they are produced can be an effective method of ensuring consumer safety.

**Table 4: Summary of tools and measures focusing on the consumer**

- Monitor and control of pesticide residues in food products of plant origin
- Setting of Maximum Residue Levels (MRLs)
- Measures to deal with non-compliant products (i.e. withdrawal of suspected products from the market, seizure of the whole lot, stricter controls to violators, etc)
- Residue monitoring in drinking water sources
- Prohibition of pesticide applications near residential areas, parks, schools, and other public places
- Information campaigns to raise consumer awareness
- Creation of internet websites to provide information to consumers
- Introduction of labels so that consumers can easily identify the methods by which products are produced (i.e. through organic farming)

# 7. Other regulatory measures

A major task along the effort to achieve a sustainable pesticide use in Europe is the creation of detailed databases on the use of plant protection products and their various impacts. To this extent, it is a legal obligation for farmers in the EU to keep records of the plant protection products they use. Records generally include information about individual applications, the commercial names of the plant protection products which were used, as well as their active substances, the type of crop to which each product was applied, the reasons for which the applications took place, the dosages and application methods, the application dates and the harvest dates. Keeping these records not only provides the basis for establishing an effective national monitoring network, but can also be a useful guide to the future use of pesticides as it helps farmers review their previous applications and improve their future plant protection activities.

Distributors and sellers of plant protection products in all EU member-countries are also required to keep records of their sales. In the Czech Republic, for example, it is obligatory, since 2004, for all entities producing or placing pesticides on sale to provide detailed data on the volume of sales of individual pesticides to the State Phytosanitary Administration (UN, Department of Economic and Social Affairs, Division for Sustainable Development). Similarly, in Belgium, sellers are required to complete special forms when selling a product intended for professional use (European Commission - FVO: Country report of Belgium, 2007). In Slovenia, marketers of plant protection products must establish and keep records on the quantities of purchased and sold PPPs, as well as evidence of stocks, and report these quantities to the competent authority (OECD, 2006).

It is also a general rule in EU member-countries that the marketing of plant protection products is restricted to persons who fulfil several conditions with regard to technical and professional knowledge on the use and properties of PPPs. Therefore, only persons acquiring a certificate of such knowledge are allowed to sell plant protection products (at least those intended for professional use) within the EU. In addition to obtaining a certificate, sellers must complete training courses. Products intended strictly for professional use, may only be sold in specialised shops that meet certain criteria in order to be authorised with selling permits, and are subject to regular inspections. With this in mind, efforts are being made across EU countries to establish the separation of pesticides into those intended for professional and those intended for amateur use.[25]

As regards the authorisation of plant protection products, each EU country has its own authorities responsible for evaluating and assessing the quality of PPPs (the content of their active substances and their physicochemical properties) and publishing a regularly updated register of authorised PPPs and their active substances.[26] When a country does not have competent staff for

[25] EC-FVO Country Profiles; OECD (2006).

[26] Detailed information about the national authorities responsible for the authorisation of pesticides in each member state is available on the European commission website, FVO Country Profiles section at: http://ec.europa.eu/food/fvo/country_profiles_en.cfm

toxicological or ecotoxicological assessments or assessments of environmental fate and behaviour, as it is the case of Cyprus, authorisations are granted on the basis of authorisations in other member-countries (European Commission - FVO: Country report of Cyprus, 2008). In some cases an administrative fee is charged for the authorisation.

The marketing and use of PPPs is controlled by authorities appointed to carry out controls at all levels, including the production, packaging, storage, distribution, imports, selling, and use of PPPs. The control is carried out by trained inspectors of the national authority responsible for monitoring. The monitoring authorities may support inspectors by issuing frequently updated procedure manuals (as in Latvia – EC – FVO, 2008), and guidelines, instructions and training programs (as in Poland – source EC – FVO, 2007). At selling points, controls may include checks regarding the presence of unauthorised PPPs and storage facilities and the user's certificate validation. At user level, checks are made for the possession and use of unauthorised PPPs, the storage of PPPs, the existence of proper application and protection equipment, and the proper keeping of spraying records.

Although competent authorities prepare the national plans for checks and inspections, additional random controls may be carried out under special conditions raising suspicion (as in Bulgaria – EC – FVO, 2007). Fines may also be imposed to violators (as in the Czech Republic – EC – FVO, 2008). National plans may also be carried at a regional level so as to better capture specific local aspects, as it is the case with Latvia (European Commission - FVO: Country report of Latvia, 2008).

Research and development in the field of plant protection is also strongly supported in the EU. Research conducted in EU member-countries covers several aspects of this issue, including risk reduction (Germany), spraying techniques, need based crop protection, organic farming and pesticide alternatives (Sweden), minimising pesticide use through biological rather than chemical controls and improved targeting of pesticides (United Kingdom), creating risk indicators (Sweden, Hungary), development of Low Dose Systems (LDS) and improvement of spraying techniques (the Netherlands), and development of forecasting and advice systems for diseases (the Netherlands). More information about this is given in OECD (2006).

Table 5: Summary of general measures towards the reduction of pesticide use

| |
|---|
| - Creation of databases on pesticide applications |
| - Requirement for farmers to keep detailed records of pesticide applications (individual applications, commercial names of used PPPs and their active substances, type of crop to which the pesticide was applied, reasons for applying the pesticide, dosages, application methods, application and harvest dates, etc) |
| - Requirement for sellers and distributors to keep records of sales |
| - Pesticide marketing restricted only to certified shops |
| - Requirement for sellers to possess a certificate of knowledge |
| - Requirement for sellers to go through training courses |
| - PPPs intended for professional use to be strictly sold on specialised and licensed shops |
| - Separation of PPPs into those intended for professional and amateur use |
| - National authorities responsible for authorising PPPs and active substances and publishing a regularly updated register |
| - Controls on the marketing and use of PPPs at several levels (production, packaging, storage, distribution, import, selling, use/farm level) by national authorities |
| - Training of the inspectors of monitoring authorities |
| - Additional help by national authorities to inspectors (procedure manuals, guidelines, instructions, training programs) |
| - Random inspections to ensure compliance at any given time |
| - Imposition of fines to violators of national laws |
| - Research and development in a wide array of topics (pesticide alternatives, risk reduction, spraying techniques, use reduction methods, risk indicators, creation of forecasting and advice systems etc) |

# 8. Pesticide taxation and other economic instruments

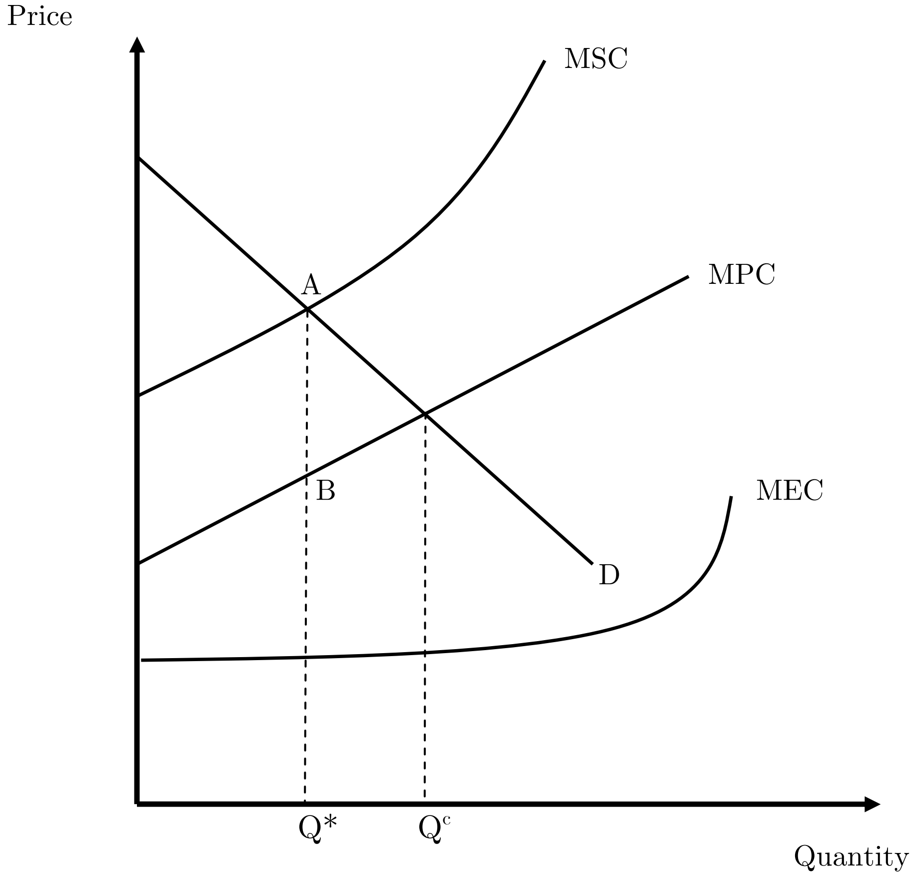
So far this paper has discussed various regulatory measures and policy tools aiming towards sustainable use of pesticides. Complementing these tools and measures are economic instruments and incentives. This section provides examples of such instruments and incentives used in several countries both within and outside the EU, with emphasis on pesticide taxes/levies/fees systems. We begin the analysis with a brief literature review of the theoretical background of the design of pesticide taxes.

## 8.1 Theoretical background

There is a substantial body of literature attempting to produce solid policy recommendations that would help countries achieve safer use of pesticides, by minimising their risks to health and the environment. Even studies that do not directly address issues of policy or regulation development can, nevertheless, be helpful insofar as they provide information which can be used for strategic planning and policy design. In Europe, for example, economic valuation has been integrated into environmental decision making, at both a pan-European and national level (Pearce and Seccombe-Hett, 2000). Within the context of environmental policy, economic valuation is an approach that can be used to assign a money value to changes in the environment. The procedure is based on people's preferences for the state of the environment and typically involves an estimation of people's willingness to pay (WTP) to achieve an improvement (or, alternatively, avoid a loss) in the quality of the environment. Thus, estimates of the WTP for reductions in pesticide use (or reductions to pesticide-related risks) can provide essential information on the levels of environmental protection that is socially desirable, or the levels of human health risks that are socially acceptable (Travisi et al.; 2006). As put by Florax et al. (2005) policy instruments such as eco-labeling, integrated pest management, pesticide bans and pesticide taxes, should preferably be related to people's WTP to reduce pesticide risk exposure. Studies undertaken on pesticide tax design are mostly based on WTP estimates. Before discussing this, however, it would be helpful to outline some key issues pertaining to the design of pesticide taxes.

To begin with, it is helpful to outline the basic problem faced by a policy maker upon the design of a pesticide tax. The textbook model for the latter is explained by Zilberman and Millock (1997). First, we assume that the use of pesticides generates social benefits. In Figure 1, these benefits are captured by the area under the curve D (Demand Curve). The private costs to the farmer applying the pesticides are captured by the area under the curve MPC (Marginal Private Cost), whereas the externality costs from pesticide use (i.e. health and environmental damages) are captured by the area under the curve MEC (Marginal Externality Cost). The total cost for the society (that is, the sum of private and externality costs) is captured by the area under the curve MSC (Marginal Social Cost). Competitive equilibrium ($Q^c$) is given by the intersection of the MPC and D curves. However, at the corresponding equilibrium price, the farmer only undertakes his or her private costs and none of the externality costs from applying the pesticides. The socially optimal level of pesticide use ($Q^*$) is given by the point of intersection of the MSC and D curves, and the optimal pesticide tax, as displayed in Figure 1, is equal to the distance AB, that is, equal to the marginal externality cost at $Q^*$.

**Figure 1: Textbook example of an externality tax**




Source: Zilberman and Millock (1997)

The introduction of taxes on plant protection products can serve two purposes.

(i) It discourages excessive use of PPPs and raises user awareness about their damaging effects, thus providing users with incentives to change their behaviour.

(ii) Tax revenues may be used to finance national actions towards more sustainable use of pesticides.

At the same time a levy on PPPs may have several effects and an important part of achieving the desired ones lies on the decisions of governments as to how to utilise tax revenues. As Oskam et al. (1998) explain, if a levy on PPPs is successful, then the use and risks of PPPs are reduced. If, on the other hand, the levy proves to be ineffective in reducing pesticide use, then the tax revenues may be used for reducing environmental effects of PPPs. Therefore, the targeting of funds generated from the imposition of a levy plays a very significant part on the overall effects of the levy.

Upon designing pesticide taxes, perhaps the most crucial implication arises because different types of pesticides have different levels of toxicity, or, put more generally, pose different levels of threats. Therefore, the application of a uniform tax across all agrochemical products may not be optimal, due to the large number of active ingredients composing the various types of pesticides, and the different levels of toxicity that these ingredients have. In these circumstances it would be more appropriate to design a scheme of differentiated tax rates, based on some measure of the hazards related to each agrochemical product (Falconer, 1998). This sort of taxation is not normally intended to stop farmers from using pesticides, but lead them away from using the more harmful types. In general, setting up an optimal tax scheme in terms of both applicability and effectiveness can be a hard task, because, there is a trade-off between economic efficiency and administrative simplicity (Falconer, 1998). Furthermore, the design and implementation of a differentiated tax involves higher costs due to higher information requirements and difficulties in enforcement (Sheriff, 2005).

Another choice faced by policy makers is whether to levy a tax on pesticide use or on pesticide price, as either way has its downsides (Falconer, 1998). For example, taxing the number of pesticide applications made can lead farmers to perform fewer but heavier applications. Similarly, a proportional tax on price may not have the desired effect when the most expensive agrochemicals are the ones causing less damage. In general, according to Falconer (1998), the key in designing environmental taxes is knowledge on the relationship between input-level and environmental damage. This relationship can be a very complicated one and, as argued by Pearce and Koundouri (2003) so can be the pesticide tax design. For example, the toxicity of pesticides varies not only by their chemical composition but also by the weather conditions during which the pesticides are applied. Furthermore, given the low price elasticity of demand for pesticides (Oskam et al., 1992) taxes may have little effect in reducing their use, unless set at a very high rate. Complications in designing an optimal pesticide tax scheme can also arise from issues concerning the use of tax revenues. For example, recycling tax revenues back into agriculture may not be as effective as using them for developing pesticide alternatives or fixing damages already done from past uses. Other revenue limitations include the fact that ad valorem pesticide tax schemes result in lower revenues when the prices decrease; and users can avoid taxes by building up stocks prior to tax increases (Falconer, 1998).

Pearce and Koundouri (2003) suggest that pesticide taxes should be expressed as the sum per unit of toxicity-weighted ingredient. Such taxes, according to the authors, may result in farmers moving towards less toxic pesticides, thereby reducing the overall toxicity pesticide use, even when the level of pesticide usage remains unchanged. The problem with this type of tax system is that the real value of the tax is eroded by inflation, and so will be the effectiveness of the scheme to discourage the use of pesticides with highly toxic ingredients. The remedy to this problem is an inflation adjustment of all the taxes imposed on toxicity units.

Pretty et al. (2001), like most studies, suggest that the ideal pesticide tax would be one placing higher costs to products causing the most harm to people and the environment. Yet this can be difficult in the absence of a credible hazard ranking methodology. The authors suggest ways around this problem, including grouping pesticides into clusters with similar impacts, ad valorem taxes, or taxes imposed on the level of use. The question is, however, what effect these taxes would have in an environment where the price elasticity of demand for pesticides is generally low.[27] Pretty et al. (2001) argue that there are reasons to believe that this elasticity is probably higher than what estimations suggest for three reasons:

(i) The low price elasticity of demand for pesticides rests on the assumption that farmers expect tax increases to be reversed at some point in the future. If tax increases are perceived by farmers as permanent pesticide demand will be more responsive.

(ii) The correct design of a tax scheme, together with an advice and incentives plan could increase farmer responsiveness to price changes.

(iii) Demand for pesticides can be more responsive to price changes over the long run as innovations in agricultural practice provide farmers with more alternative methods to protect crops.

In a more general context, another important question is what exactly the ‘desired’ level of PPP use is. Bürger et al. (2008) discuss this topic in an attempt to provide a theoretical framework for making decisions about the ‘appropriate level of pesticide use’, defined as the level necessary to control a pest on a crop. The authors discuss three different ways of defining this level of pesticide use:

(a) Using an agrochemical product at the proposed dosage only when a pest is detected, or as a precautionary measure when it is thought necessary,

(b) Reducing pesticide use to the minimum necessary dictated by cost-benefit analysis, and

(c) Reducing pesticide use by optimising the cultivation system so as to lower the risk of pest infestation.

The authors reach the conclusion that a combination of the second and third approach could result in the smallest pesticide use intensity. In addition,

[27] Some examples of the price elasticity of demand for pesticides are extracted from Rayment et al. (1998): Estimates for the Netherlands, Greece, France, Germany, Denmark and the UK are typically between -0.2 and -0.4 with some ranging up to -0.7 to -1.0.

they argue for defining as 'necessary' the pesticide use which is still required after all other feasible non-chemical measures of plant protection are exhausted.

Falconer and Hodge (2001) examine the linkages between the multi-dimensionality of ecological problems and the complexities associated with policy design. Pesticides present a difficult problem to trace in the sense that their hazardous effects are to a large degree uncertain in terms of extent, duration, and scale. Given this complexity, Falconer and Hodge (2001) argue that rather than eliminating and treating each aspect of environmental quality problems individually, it is best to consider them all jointly, by taking a multi-dimensional approach to policy formulation. To achieve sustainable use of plant protection products it is necessary to find a balance between, economy, ecology and social aspects (Bürger et al., 2008). It is therefore essential to accept the fact that there may have to be trade-offs between these aspects, and, consequently find some compromising solution. Falconer and Hodge (2001) suggest that the ideal policy plan would be one which creates incentives for farmers to move towards more pesticide-free cultivation methods, rather than trying to adjust their application habits. Within this context, the authors propose that all policy schemes should have advice and education at the core of their strategies.

In order to provide empirical support for their arguments Falconer and Hodge (2001) use farm-level data from a UK cereals farm. They combine an economic model of land use and production with a set of constructed hazard indicators for pesticides to identify the possible trade-offs between reductions in environmental damages and the income of farmers. Consequently they consider four economic incentive policy instruments: an ad valorem tax, a fixed levy per spray unit, a levy per kilogram of active ingredient, and a levy based on the pesticide hazard score (hazard assessment was made in the paper). The results show that the different specifications of a pesticide tax have different impacts in terms of both magnitude and direction, and may also present negative side-effects. This is interpreted by the authors as an indication that in terms of policy design, compromises may have to be made, or additional policy instruments should be introduced.

As mentioned in the previous sub-section, WTP estimates can be utilised towards the formulation of pesticide taxes. Mourato et al. (2000) illustrate this by showing how WTP estimates can be used in the design of a tax to avoid pesticide damage in the UK. The proposed procedure is to divide the aggregate WTP over a given time period by the total volume of pesticide used in crops over the same period.[28] Due to lack of detailed data two simplifying assumptions

[28] Aggregate WTP can be calculated by multiplying the marginal WTP in terms of money per unit of agricultural product per unit of damage, by the total environmental damage figures and by the aggregate number of units of agricultural product purchased each year, adjusted by its price elasticity.

are made: (a) the total cereal yield in the UK is allocated exclusively to bread production (the agricultural product investigated in this study), and (b) each loaf of bread corresponds to one unit of damage. The uniform tax estimated in this study is 12.59 STG per kilo of pesticides. This value represents a tax rate over 60% of the pesticide price per kilo.

Chalak et al. (2008) work in somewhat similar fashion when they examine the public's WTP for reductions in the use of pesticides in agricultural production in the UK, with a view to combat the impact of pesticides on human health and the environment. The authors focus on two categories of agricultural production through which pesticide use creates risks for human health and the environment: (a) cereal production (linked to environmental effects of pesticides) and (b) fruit and vegetable production (linked to human health effects of pesticides). To place their results within a policy context, the authors consequently estimate pesticide taxes based on their WTP estimates. More specifically, they calculate the level of a pesticide tax required for a certain reduction in pesticide use, according to their WTP estimates for each type of agricultural production. To do this they first make a number of simplifying assumptions, regarding the amount of pesticides used in each type of production, the level of environmental impact produced by each unit of final agricultural product, the level of imports and exports of these products, and the level of consumption of agricultural products. Thereafter, following the method employed by Mourato et al. (2000) the authors calculate the (uniformly distributed across all pesticides) taxes required to achieve a 5% reduction in pesticide use for each of the two types of agricultural production. Interestingly, their estimates show that a much higher (nearly ten times as much) tax is required to reduce pesticide effects on human health than that required to reduce their environmental effects. Specifically for pesticides used in fruit and vegetable productions, the tax rate estimate is equal to 128,9 STG per kilo of active ingredient, whereas for cereal production the related tax is estimated is only 14 STG per kilo of active ingredient.

The two studies described above present an illustration of how WTP estimates can be utilised in the design of a uniform tax across pesticides. However, as explained in Mourato et al. (2000) such a tax does not present farmers with an incentive to move towards using more user- or environmental-friendly pesticides. In effect, uniformly applied pesticide taxes cannot guarantee desired effects. To differentiate the tax one needs a technique estimating the full range of effects attributed to a plant protection product, or rank pesticides according to the level of risks they pose. The survey conducted by Mourato et al. (2000) considers respondents' attitudes towards different kinds of damages and this gives rise to non-uniform tax rates ranging from 11.38 STG to 13.69 STG per kilo of agrochemical product - instead of the uniform tax 12,59 STG per kilo estimated originally.

## *8.2 Tax policy*

Pesticide taxation has been implemented in several counties inside as well as outside the EU. Three Scandinavian countries, namely Sweden, Norway, and Denmark, introduced pesticide taxes as part of their efforts to reduce pesticide use. Among the three, Sweden was the first country to establish pesticide taxation, in 1985. The Swedish system is also the simplest among the three and works as an environmental levy per kilo of active substance. Originally the levy was 20 Swedish Krona (SEK) per kilo of active substance, but in 2004 it was raised to 30 SEK (PAN Europe, 2005).

Norway introduced pesticide taxation in 1988. Originally, Norway's taxation system was based on a flat rate tax on the value of imported pesticides divided into a control tax (9% of the base price) and an environmental tax (15.5% of base price) (Rørstad, 2005). In 1999 the taxation of pesticides changed into a system of differentiated rates according to health and environmental risks (PAN Europe, 2005; Rørstad, 2005). The new system allocates pesticides into six tax brackets based on health and environmental risk (low, medium and high risk) and whether they are ready or concentrated hobby products or seed treatment pesticides). The first three refer to pesticides intended for professional use.[29] The pesticide tax is calculated by multiplying the basic tax of 20 Norwegian Krona (NOK) per hectare by the factor corresponding to the class which the pesticide belongs to. For example, the factor for high risk pesticides is 8, so the tax levied on pesticides classified as high risk is 160 NOK per hectare. In addition, Norway also imposes a control tax of 16 NOK/hectare to all pesticides sold to recover the cost of testing, controlling, and registering pesticides.

Denmark's tax system, does not classify pesticides by their toxicity or health and environmental risk properties. Instead, the tax on pesticides is based on the maximum retail price and applies higher rates to pesticides that are cheaper. The current tax rates are 53.85% for insecticides, 33.33% for herbicides and 33.33% for fungicides (Danish Environmental Protection Agency, 2000). The tax is applied at the manufacturing or importing stage but, unlike the Norwegian pesticide tax system, tax rates do not reflect environmental and health hazards. Also, 75% of tax revenues are returned to farmers in the form of lowered property taxes, while the rest is used for research purposes and pesticide use reduction programs. These provisions dampen farmers' objections to pesticide taxation (PAN Europe, 2005).

Little is known about the effectiveness of taxation in the three Scandinavian countries discussed above because this effect cannot be separated from the

[29] In October 2004 modifications were made to the system, including making the classes for pesticides used professionally increased from three to five (PAN Europe, 2005).

effects of other measures taken to reduce pesticide use. However, a survey in PAN Europe (2005) shows that 40% of Norwegian farmers surveyed said that taxation has led them towards using less toxic pesticides. Danish officials consider pesticide taxation to have contributed to a 5% decrease in the use of pesticides; whereas in Sweden taxation is not believed to have had any substantial effect in terms of pesticide use between 1998 and 2002.

Belgium introduced pesticide taxation on pesticides bought for agricultural use in 1998 (OECD, 2007). This tax applies to five active substances and its primary purpose is to finance PPP registration and Belgium's federal programme for reducing the use of pesticides and biocides in agriculture. The tax is based on several criteria (such as health and environmental risks, and flammability) and is paid by marketing authorisation permits. The tax was initially low (only 0.0025 Euro per gram of active substance) and well received by farmers. However, it has since increased to 0,395 Euro per kilo or litre of pesticide with a view to creating stronger incentives for producers and users to turn towards safer plant protection products (OECD, 2007).

In 2000, Italy introduced a 0.5 % flat tax over the final price of all the pesticides manufactured and sold which (a) create cumulative risks, (b) are linked carcinogenic effects, (c) can cause cancer, and (d) can impair fertility. A flat tax of 1% over the final price of imported pesticides was also introduced at the same time. The revenues collected from the tax are used to finance the development of organic farming and quality products (PAN Europe, 2005).

France applies a tax on seven categories of pesticides as non-point sources of water pollution. The tax rates are 0.00, 381.12, 609.80, 838.47, 1067.14, 1372.04 and 1676.94 Euro per ton of plant protection products, reflecting the different levels of pollution generated by each pesticide category (OECD-EEA website).

The UK introduced in 1987 a levy on pesticide products approved by the Health and Safety Executive (HSE) to cover the monitoring costs of pesticide use. The tax levy varies with the sales turnover and its collection begins in September each year by requesting approved suppliers to declare their annual turnover. For the 2007-08 period the levy rate was estimated to be below 0.6% of gross turnover. This is, of course, very low by comparison to other EU countries; however, as said above, the tax levy in the UK is not intended to curb pesticide use but finance the HSE's monitoring costs (HSE website).

In Finland pesticides are subject to a registration and control fee. The registration fee is 840 Euro payable when a pesticide product enters the market, whereas the control fee is 3.5% of the product's retail price (excluding VAT). The main purpose for the collection of the fee in Finland is to cover the administrative expenses for the registration of pesticides (Parkkinen, 2008).

Table 6: Summary of pesticide taxes and fees in EU countries

| Country | Year introduced | Details | Taxes/Levies |
|---|---|---|---|
| Sweden[1] | 1985 | - First Scandinavian Country to impose a tax on pesticides.<br>- Simple system.<br>- Environmental levy per kg of active substance. | - Originally 20 SEK per kg active substance.<br>- From 2004: 30 SEK per kg active substance. |
| Norway[1] | 1988 | - Originally flat rate tax (percentage) on import value of pesticides.<br>- In 1999 it was changed to a system based on health and environmental properties.<br>- Taxation takes into account human health and environmental risks (risk reduction approach)<br>- Emphasis on risk indicators, assessed through a series of intrinsic hazard and exposure scores.<br>Pesticides are sorted into different classes based on their effects on health and the environment. Each class has a different tax factor.<br>- Goal is to reduce the use of pesticides, particularly those with that pose the highest threat to human health and environment. | - Basic Tax: 20 NOK per hectare<br>To calculate tax for each pesticide product, basic tax is multiplied by the factor of its class:<br>- Low health and environmental risk: 20 NOK/ha (20x1) (factor=1)<br>- Medium health and environment. risk: 80 NOK/ha (20x4) (factor=4)<br>- High health and environm. risk: 160 NOK/ha (20x8) (factor=8)<br>- Seed treatment pesticides: 10 NOK/ha (20x0.5) (factor=0.5)<br>- Concentrated hobby products: 1000 NOK/ha(20x50) (factor=50)<br>- Ready hobby products: 3000 NOK/ha (20x150) (factor=150)<br>Additionally a standard levy of 16 NOK/ha for all pesticides sold also applies. |
| Denmark[1] | 1992 | - System based on pesticide prices.<br>- Tax levied as percentage of the retail price of pesticides (excluding VAT).<br>- Higher tax to cheaper pesticides.<br>- Taxation system does not consider hazards or risks. | - Insecticides: 54% of retail price (excl VAT)<br>- Herbicides: 33% of retail price (excl VAT)<br>- Growth Regulators: 33% of ret. pr. (excl VAT)<br>- Fungicides: 33% of retail price (excl VAT) |

(continued on next page)

Table 6 (continued)

| Country | Year introduced | Details | Taxes/Levies |
|---|---|---|---|
| Belgium[1,2] | 1998 | - Tax on pesticides with primary purpose of financing PPP registration and the Federal Programme for Reduction of Pesticide Use in Agriculture and Biocides.<br>- Tax applies to five active substances<br>- Tax is based on several criteria (health and environmental risks, and flammability). | - Original plan for the tax was €0,0025 per gram of active substance.<br>- Since 1998, tax rates have been increased to up to €0,395 per kilo or litre of pesticide, to create incentives for both producers and users to turn towards safer products. |
| Italy[1] | 2000 | - Flat tax to all pesticides manufactured and sold with the following risks:<br>(a) risks of cumulative effects<br>(b) limited evidence of carcinogenic effect<br>(c) may cause cancer<br>(d) may impair fertility<br>- Higher Flat tax to imported pesticides. | - Flat tax: 0.5% over the final price for pesticides manufactured in Italy.<br>- Flat tax: 1% over the final price for imported pesticides. |
| France[3] | | - Tax on seven categories of pesticides as non-point sources of water pollution.<br>- French Tax is designed to reflect the different levels of pollution generated by each pesticide category. | - Category 1: 0.00 Euro per tone<br>- Category 2: 381.12 Euro per tone<br>- Category 3: 609.80 Euro per tone<br>- Category 4: 838.47 Euro per tone<br>- Category 5: 1067.14 Euro per tone<br>- Category 6: 1372.04 Euro per tone<br>- Category 7: 1676.94 Euro per tone |
| UK[4] | 1987 | - Pesticide levy charged each year on Health and Safety Executive (HSE) approved pesticide products, based on their sales turnover.<br>- Levy is charged to the agrochemical industry.<br>- Levy is intended to cover monitoring and approval costs. | For 2007/8 estimated to be below 0,6% of gross turnover |
| Finland[5] | 1988 | - Registration and control fee on pesticides.<br>- Used for the purposes of covering the administrative expenses for the registration of pesticides. | - Registration fee for new product to enter the market: 840 Euro<br>- Additional fee of 3.5% of product's retail price (excluding VAT) |

Sources: [1] PAN Europe (2005)

[2] OECD (2007)

[3] OECD-EEA (website)

[4] Health and Safety Executive UK (website)

[5] Parkkinen (2008)

In addition to pesticide taxes and levies, an alternative economic instrument which may assist the promotion of sustainable pesticide use is a subsidy The use of subsidies to reduce pesticides takes the form of financial assistance paid to users as an incentive to turn them towards more environmentally-friendly practices. Examples of how subsidies are used in EU countries to combat pesticide risk include the following:

- The Netherlands subsidises (a) training programs in integrated pest management initiated by farmers, (b) farmers applying mechanical weed systems and reducing herbicide use to less than a kilo per hectare (this subsidy comes from the EU), (c) the advertising of products certified as produced by good agricultural practices, and (d) research related to risk reduction methods on the condition that the results are communicated to farmers (OECD, 2006).

- In Germany, a large number of farm enterprises take part in the agro-environmental programs of the Federal Länder, which are co-financed by the EU. In addition, research and development towards PPP risk reduction in Germany is funded by various organisations, ministries and the Federal Länder (OECD, 2006).

- In Slovenia, special financial support is provided to ecological farming, integrated arable farming, integrated fruit growing, integrated vine growing, and integrated vegetable growing (OECD, 2006).

- In Luxemburg, farmers receive subsidies for keeping records on PPP applications, for receiving a certification for their spraying equipment every five years, and for keeping PPPs in safe storage (European Commission - FVO: Country report of Luxemburg, 2008).

- In Austria, financial support is provided for the development of forecasting systems (Lentsch, 2007). Belgian regions also finance research activities and support advisory services (von Bol, 2007).

## 9. General comments and country approaches

National policies aiming to influence the use of plant protection products differ significantly from one country to another because, as mentioned earlier, each country adapts its actions to its own needs and characteristics. In the EU Expert Meeting on National Plans and Programmes for the Reduction of Risks

Associated with the Use of Plant Protection Products, which took place in Berlin in 2007, several EU member-states presented their plans and activities on the issue of sustaining pesticide use.[30] This section provides some general remarks on the actions taken by various countries, and highlights key characteristics of different country approaches.

Some countries do not have an integrated national plan focusing on eliminating the risks generated from the use of PPPs. Instead, this task is implemented through various national programs. Austria, for example, combines various programs, measures and provisions from different legal fields that are implemented both at national and regional level. Popular among these is the Austrian agro-environmental Programme which is carried out throughout Austria. A number of measures in the programme are related to plant protection. These include (a) the promotion of organic farming, (b) integrated production measures, (c) inspections of existing plant protection equipment and (d) the renunciation of inputs (Lentsch, 2007). Similarly, in Hungary the national agro-environment programme focuses on supporting organic and ecological farming and integrated crop production (Tóth, 2007).

It is also the case that in some countries legislation regarding PPPs is undergoing reforms. Finland, for example, introduced a new act on PPPs in early 2007. In Finland's case, although no official action plans have been approved, the agro-environmental programs which have been in effect during the last two decades or so, aim at reducing the harms caused to the environment by pesticide use. These programs especially target the protection of surface and ground waters, the air, and the rural landscape. Measures taken in the context of these programs promote the use of pesticides primarily through need-based applications, crop rotation, integrated pest control methods and the development of forecasting systems. Furthermore, Finnish farmers must attend training every five years and, in addition, they are supported by the current agro-environmental program through additional training and advisory services. Other Finnish measures include the obligatory testing of spraying equipment on a five-year basis, the imposition of strict restrictions with regards to the use of certain products in specific areas or on specific types of crops, the requirement for professional users to obtain a certificate of knowledge in order to be able to purchase certain (very hazardous) PPPs, and the requirement for farmers to keep records of their applications. It is important to comment, that in Finland's case the cold climate and short growing season keep the requirements for chemical crop protection low (Autio and Hynninen, 2007).

[30] Julius Kühn-Institut (website).

On the other hand, there are countries with specific strategies focusing directly on pesticides. Belgium, for example, has undertaken a programme aiming to reduce the use of pesticides and biocides. For the agricultural sector, the goal of the program is to reduce by the year 2010 the risks associated with pesticide use to 25% of what they were in 2001. Participants in the programme are mobilised through attending meetings and seminars and taking part in research activities. Several committees are responsible for the collection of information and opinions about risk management issues. In general the programme seeks to carefully study the problems associated with pesticides and biocides and, consequently, take action by modifying user behaviour, agricultural production techniques and adjusting the relevant legislation. With regard to the latter, Belgium has already proceeded into the division of the registration of plant protection products between those intended for professional and amateur use. Other actions which have been or will be undertaken in the context of the programme include the promotion of organic farming, the establishment of training courses, the possession of a certificate of knowledge as a prerequisite for professional users to purchase highly toxic products, and the general improvement of pesticide registration activities. Lastly, in order to investigate all aspects of the problem, several actions are taken in order to (a) monitor pesticide and biocide sales and consumption, consumer exposure and market structure (b) set up a representative dataset, allowing the assessment of pesticide-related risks every two years, and (c) develop a set of risk indicators (von Bol, 2007).

Similarly, Denmark and France have set up specific action plans for monitoring and controlling pesticide use. Denmark is currently implementing a national plan in connection with the amendment of Council Directive 91/414/EEC on the placing of PPPs and with the thematic strategy on the sustainable use of pesticides in the EU. The plan seeks to reduce the use of pesticides in agriculture and reduce their environmental and health effects in horticulture and fruit growing.

- To reduce the use of pesticides Denmark seeks to reduce the treatment frequency index and promote pesticide-free cultivation techniques. Actions taken towards this goal focus primarily on enhancing farmer knowledge and the promotion of methods of cultivation and pest control that avoid or limit the use of pesticides, like precision farming (applying pesticides only to the specific areas where pests are present), mechanical or partly-mechanical control of weeds and organic farming.
- To reduce the environmental and health effects of pesticides attention is paid to monitoring pesticide residues in foodstuffs. The enhancement of available knowledge on pesticides and their properties, and the circulation of information towards users is also an important component of the Denmark plan. Other measures include (a) financing research projects, (b)

identifying sensitive areas and enforcement of restrictions so as to reduce groundwater pollution, (c) training farmers with regard to the proper use and cleaning of application equipment so as to reduce point source pollution, (d) establishing buffer zones and (e) informing private/home users about pesticide properties so as to reduce private consumption (Danish Ministry of the Environment and Danish Ministry of Food, Agriculture and Fisheries, 2007).

In France the ministries of Health, Agriculture, Ecology, Competition and Consumer Protection and Repression of Fraud, have collaborated to produce an inter-ministerial plan with two purposes: reduce the use, presence and impacts of pesticides; and create a database of available scientific data on these products and their impacts (Duclay and Casala, 2007). The plan has five goals, each with its own targets and regulations. The first goal is to enhance the procedures through which pesticides are placed on the market by (a) conducting benefit-costs analyses for PPPs, (b) limiting the market release and use of highly toxic products, (c) reforming the system that approves PPP users and distributors, (d) enhancing the training and advisory services for all parties involved (sellers, distributors, users etc), (e) improving transparency about products which are identical, and informing users about new products being placed on the market, (f) ensuring that pesticide distributors keep sales registers, (g) prohibiting the sale of professional products to amateur users, (h) restricting aerial spraying to certain products, (i) creating a regulatory framework which controls the use of hazardous mixtures, and (j) developing and conducting surveys addressing occupational accidents and illnesses related to the use of pesticides (Duclay and Casala, 2007).

The French programme also focuses on the promotion of alternative farming practices and the minimisation of the use of pesticides. Measures taken for this goal include the promotion of practices and production procedures which minimise the need for applying pesticides. This is pursued through the development of farming systems that use PPPs at a very low level, the promotion of integrated plant production farming systems, financial support to organic farming, and provision of financial aid to water agencies so as to cope with pesticide-generated water pollution. Furthermore, the French program includes measures towards reducing pesticide leaks into water such as specifying safety or non-treatment zones, improving the quality of application equipment through regular inspections and by imposing minimum quality standards to new or used spraying equipment sold, and taking actions towards the protection of drinking water from pesticides (Duclay and Casala, 2007).

Enhancing existing knowledge on pesticides and improving the management of pesticide waste and reducing pollution from point sources also figure high in the priorities of the French plan (Duclay and Casala, 2007). To accomplish this the plan seeks to: (a) enhance the training of professional users and distributors through the establishment of a framework for the specialised training of professional distributors and users, in which the aspects of health and environmental risks are well incorporated, the establishment of five-year obligatory safety training (both theoretical and practical) for farm workers exposed to pesticides, the incorporation of health and environmental dimensions in worker training courses, and by publishing professional guidelines; (b) improve user protection and provide better information to them through establishing certain safety standards that need to apply in workplaces, promoting the best protection equipment and informing the agricultural sector about what equipment is available on the market, harmonising product labeling and improving label legibility so as to better inform users, and enhancing the training of official pesticide work inspectors; and (c) improve the general knowledge with regards to pesticides and their impacts on the environment and human health through research projects, studies, collection of information and evaluation of the progress made during the implementation of the plan (Duclay and Casala, 2007).

Germany has also introduced a programme specifically focusing on reducing pesticide-related risks, minimising the intensity of pesticide use and reducing the percentage of consumer products which exceed the existing maximum residue limits, to less than 1%. Actions proposed by the program include: (a) the introduction of a treatment frequency index; (b) the creation of a network of reference farms providing annual treatment index data, background information on the necessity of pesticide applications and examine possibilities for reductions in pesticide use in the future; (c) the support of research, development and implementation of integrated plant protection; (d) the setting of Maximum Residue Limits; (e) the enhancement of the knowledge of professionals; (f) the establishment of pesticide use records, (g) the improvement of inspection procedures; (h) the development of new plant protection equipment; (i) the support of integrated pest management and organic farming; and (j) the enhancement of the information available to consumers (Freier, 2007).

The Netherlands has set out specific targets to be achieved by 2010, through its third National Action Plan. This plan focuses on reducing the impact of PPPs on surface water and consequent drinking water problems and reducing the percentage of consumer products in which pesticide residues exceed the maximum limit. It introduces legislation covering, amongst other things, the authorisation of PPPs, the protection of workers, residue monitoring and integrated pest management. The plan also provides for measures targeting the reduction of the impacts of PPP use, such as improving knowledge, farmer training, promotion of alternative pest control methods and keeping enough plant protection products available, so as to sustain the competitiveness of the Dutch agriculture (Knol, 2007). To measure the progress made, risk indicators are developed by the Netherlands Environmental Plan Bureau.

The UK has also developed a very thorough strategy towards the sustainable use of PPPs through five action plans addressing (a) the protection of water quality, (b) the reduction of biodiversity losses generated by pesticide uses, (c) the promotion of best practices and management techniques for amateur users of pesticides, (d) the protection of water and biodiversity from amenity uses of pesticides, and (e) ensuring the availability of necessary resources (products, tools, and techniques) to those involved in plant protection. These action plans incorporate measures promoting pesticide legislation and risk assessment processes, the establishment of links with and the provision of support to related government initiatives, the encouragement of industry and voluntary initiatives (as regards training, information sharing equipment testing etc), the communication and consultation with all the stakeholders, and the promotion of research and development and the transfer of knowledge (DEFRA UK, 2006; Stark and Dixon, 2006).[31]

## 10. Concluding remarks

The use of pesticides in modern agriculture has without undoubtedly aided worldwide farmer productivity. However, extensive use of chemical plant protection products has resulted in numerous side effects causing harm to both the environment, and the health of farmers and consumers. To prevent this, measures are being taken throughout the EU so that the use of these products is brought down to a sustainable level. EU legislation covers a wide array of themes, including the evaluation and authorisation of chemical substances used in modern agriculture, the monitoring of their residues in agricultural food products, and the safeguarding of environmental quality. In addition, the existing legal framework in the EU has been reinforced with the adoption by the European Commission of the "Thematic Strategy on the Sustainable Use of Pesticides", which focuses on controlling the use stage of pesticides and promotes research and development of alternatives.

In addition to the general EU legislative framework, member-countries have also introduced measures at a national level to promote sustainable use of pesticides. Some countries have developed national plans aiming at minimising the risks of pesticide use, while others incorporated pesticide risk reduction within the framework of other national programs. There are also cases where country legislation is currently being reformed. Despite the fact that national approaches may differ, several policy tools are broadly used within EU member-states. This paper has categorised these measures into those which primarily

[31] Additional detailed information on the UK's National Pesticides Strategy can be viewed at: http://www.pesticides.gov.uk/uploadedfiles/Web_Assets/PSD/PB11721_Pesticidesenvironment_Lo.pdf

target the farmer, the environment, the consumer, and overall pesticide use reduction.

Taxes/levies/fees on pesticides have been introduced in several countries worldwide, even though in some cases the primary objective is merely to cover monitoring costs rather than influencing user behaviour. In addition economic incentives, subsidies and other forms of financial support have also been introduced in EU member-countries to promote safer agricultural practices and stimulate research on this subject. Yet, the policies aimed at controlling pesticide use, in particular the design of pesticide taxes, has a wide range of implications that need to be investigated.

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