Sustainable Use of Pesticides

Written by: Laszlo Pinkoczi
Agribusiness and Rural Development Engineering
2013

Seminar Representative: Dr. Jambor Attila
Én, Pinkóczi László teljes felelősségem tudatában kijelentem, hogy a jelen szakdolgozatban szereplő szövegrész, ábra és táblázat – az előírt szabályoknak megfelelően hivatkozott részek kivételével – eredeti és kizárólag saját munkám eredménye, más dokumentumra vagy közreműködőre nem támaszkodik.

I, Laszlo Pinkoczi declare, that the content (text, graphs and figures) of this thesis – except the parts where the sources are marked by prescribed rules – original and the result of my own work, it does not lean on other document or collaborator.
Table of contents

ACKNOWLEDGMENTS ........................................................................................................... V

LIST OF ABBREVIATIONS ..................................................................................................... VI

1. INTRODUCTION ............................................................................................................ 1

2. PESTICIDES IN GENERAL AND STATISTICAL DATA FROM THE EUROPEAN UNION .. 3
   
   History of pesticides in brief .............................................................................................. 5
   Facts from the European Union .......................................................................................... 6
   The Pesticides ...................................................................................................................... 11

3. LEGAL BACKGROUND OF SUSTAINABLE USE OF PESTICIDES ......................... 13


4. SUSTAINABLE USE OF PESTICIDES IN THE NETHERLANDS AND TECHNOLOGICAL
   SOLUTIONS ....................................................................................................................... 17

   1. Promoting integrated crop protection .............................................................................. 17
   2. Producers of environmentally hazardous chemicals or harmful products have to supply emission
      mitigation plans ................................................................................................................ 18
   3. Waste water management in greenhouses from 2016 ..................................................... 18
   4. Safety zone enlargement .................................................................................................. 18
   5. Drift reduction regulation system in the Netherlands ...................................................... 19
   6. Promoting activities in point source risk management. (Cleaning, filling, remnants) ....... 26
   7. Further activities on personnel safety ............................................................................. 33
   8. Current spray license will be enhanced for farm owners ................................................ 33
   9. Additional sprayers need to be tested and certified........................................................ 33
   10. Professional weed control on hard surface areas ............................................................ 34
   11. The government should apply more control on obeying the rules. This step specifically covers fruit,
       greenhouse and bulb flower production ........................................................................ 34
   12. Indicators: the HAIR2010 (Harmonized environmental indicators for pesticide risk .......... 34

5. WHAT HUNGARY CAN APPLY FROM THE DUTCH NAP? ........................................ 36

   Comparing the Hungarian NAP to the Dutch NAP ........................................................... 39

   RESULTS .................................................................................................................................... 40

   DISCUSSION OF THE RESULTS .......................................................................................... 40
6. CONCLUSION AND RECOMMENDATIONS .......................................................... 42

Conclusion ........................................................................................................ 42
Recommendations .............................................................................................. 43

BIBLIOGRAPHY .................................................................................................. 45

LIST OF FIGURES ............................................................................................... 50

APPENDICES ....................................................................................................... 51
Acknowledgments

Herewith I would like to signify my appreciation to all those people who supported me to write this thesis, especially to the whole Marketing Department at John Deere Fabriek, Horst. I would like to say a special acknowledgement to Eric Teuwsen who had provided me numberless relevant information for my thesis work and coordinated me during the whole writing process.

Furthermore, I would like to thank my course coordinator Taco Medema. He provided me very beneficial recommendations to finish my thesis in a good order.

Last but not least I would like to express my special thanks to my family. They encouraged me during this period and gave me mental support until the end of the writing process.
**List of abbreviations**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMP</td>
<td>Best Management Practices</td>
</tr>
<tr>
<td>CAP</td>
<td>Common Agricultural Policy</td>
</tr>
<tr>
<td>ECPA</td>
<td>European Crop Protection Authority</td>
</tr>
<tr>
<td>EQS</td>
<td>Environment Quality Standards</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>ESFA</td>
<td>European Food Safety Authority</td>
</tr>
<tr>
<td>HAIR2010</td>
<td>Harmonized Environmental Indicators for Pesticide Risk</td>
</tr>
<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>JKI</td>
<td>Julius Kühn-Institut</td>
</tr>
<tr>
<td>MRL</td>
<td>Maximum residue level</td>
</tr>
<tr>
<td>NAP</td>
<td>National Action Plan</td>
</tr>
<tr>
<td>PPP</td>
<td>Plant Protection Product</td>
</tr>
<tr>
<td>SDRT</td>
<td>Spray Drift Reduction Technology</td>
</tr>
<tr>
<td>SKL</td>
<td>Stichting Kwaliteitseisen Landbouwtechniek</td>
</tr>
<tr>
<td>TOPPS</td>
<td>Train the Operator to Promote best Practices and Sustainability</td>
</tr>
<tr>
<td>UAA</td>
<td>Utilized Agricultural Area</td>
</tr>
<tr>
<td>UR</td>
<td>University</td>
</tr>
<tr>
<td>WFD</td>
<td>Water Framework Directive</td>
</tr>
<tr>
<td>WWII</td>
<td>World War II.</td>
</tr>
</tbody>
</table>
1. Introduction

This research is needed because global circumstances are changing, input costs including chemical costs are increasing and environmental requirements are also expanding. This research could be beneficial for farmers, machinery and equipment producers, chemical producers and decision makers as well.

The main question to answer is what Hungary could do to improve the National Action Plan in order to develop a more efficient sustainable pesticide use strategy. To develop the final recommendation further questions should be answered. What is the legal background of pesticide use currently in the European Union and more detailed in the Netherlands? What are the latest available technological measurements in spraying application? What Hungary can use from the Dutch system?

The motivation was to develop some recommendations for Hungary in pesticide use. Because of the company placement – which was at John Deere Fabriek, Horst –this question is being approached more by the praying application aspect.

The term of sustainable pesticide use is quite new. In May, 2013 the ECPA published the latest document about diffuse source management. However this document is available only in English. This proves the fact that the development of PPP use is really at the beginning. The member states of the European Union will implement these regulations and technological requirements soon. The countries such as Netherlands, Denmark, Germany or the United Kingdom already have a successful sustainable pesticide use methodology. These countries could be perfect precedents for the member states which currently have a sufficient methodology or even do not have at all.

During the placement period several meetings and discussions were set up to gather all the relevant information from experts who are really involved into the topic and can provide trustworthy information. An interview was also made to represent the opinion of Eric Teuwsen who is responsible for current sprayers at the marketing department and knows everything about the machines, pesticide use and current situation around the Netherlands. Further on, several PDF documents are available on the internet, mostly on
the website of the European Crop Protection Authority or the European Food Safety Authority. For the statistical data the EUROSTAT database was used. This database can provide really up to date and precise information about agriculture in the member states. The thesis is divided in four main chapters. In the first chapter the reader can find some statistical figures in order to have a clearer overview about agricultural activities and trends in Hungary and Netherlands comparing to the EU – 27.¹ In the second chapter the legal background of pesticides is described. It covers the machinery, sustainable pesticide use, placing PPPs on the market and the water framework. In the third chapter the Dutch situation regarding to sustainable pesticide use is described. This chapter is the longest and the most important. Here the reader can find information about the current technologies in order of sustainability and environmental protection. Both technological and theoretical information can be found in this chapter. In the last part the main research question is answered: What Hungary can use from the special Dutch measurements?

¹ During the thesis work, Croatia was not a member state of the European Union yet.
2. Pesticides in general and statistical data from the European Union

These days the global food chain is facing the most remarkable challenges. Population is growing continuously; by 2050 there will be 9 billion people worldwide. On the other hand the available fields for agricultural activities will be the same or even less. Because of the experienced climate and other environmental issues, the question of sustainability has more and more attention, which can be attained by using the available resources today in a way that assures the same standard of living for the future generation as well. The previously mentioned issues have effects on air, water and soil quality in the same time. Global agricultural sector also has to take the notion of sustainability into consideration. The primary object is obviously to provide sufficient amount of food supply while protecting the environment and attaining a sustainable agribusiness.

From another aspect the global economic situation is in the black, costs of inputs are very vital for farmers. It implies for instance the seed prices, labor work, fuel and machinery and chemicals as well.

Regarding Europe, the European Union is also focusing on sustainability and climate change. The EU has to respond to environmental, territorial and economic challenges. In doing so, they need to take care of food security, soil depletion, water/air quality, vitality of rural sources and diversity of EU agriculture. The European Union has developed a program in order to tackle the future’s challenges. The strategy called EUROPE 2020\(^2\) sets specific goals and recommendations for the member states in education, energy efficiency, research and development, climate change, and renewable energy.

Since the agricultural activities are one of the most significant polluters, the Europe 2020 strategy is not possible to implement without a successful reform in the common agriculture.

In the development of Common Agricultural Policy (further: CAP), a trend can be defined from productivity through a competitiveness phase to sustainability. On the following table the development steps of the CAP are represented.

\(^{2}\) Internet Source [6.]
Since 2003 the CAP has already been enforcing farmers to do a sustainable agribusiness. The supporting system (Cross Compliance) was also developed focusing on this aspect. Farmers are able to receive direct financial support from the EU budget, but they have to fulfill a lot of requirements and rules regarding the environment protection, soil protection, animal marking, food safety, animal and plant care, and welfare, otherwise the amount of subsidy will be reduced, revoked or banned.

Due to the fact, that the EU is encouraging the development of an environmentally friendly agriculture, the CAP will have an effect on pesticide use as well. The main goal is to decrease the application of pesticide throughout Europe and implement new technologies in crop care to avoid further pollution. The elements of the Cross Compliance are the following:

- Use of certified pesticides only
- The application of pesticides regulations
- Sufficient level of education
- Administration of spraying
- Administration of pesticides
- Storing the equipment

---

3 Written source [3.]
4 Written source [13.]
- Repacking pesticides
- All of the applied machines need to be in a sufficient condition

Plant protection is getting more and more complicated. Currently the farmers have to take into account a lot of regulations to run or even to start up a new business in agriculture. As a scenario in the future it is possible, that the content of cross compliance will be expanded with further requirements in sprayer machinery equipment and pesticide handling.⁵

**History of pesticides in brief**

The European Union adopted a strategy on pesticides in 2006. The main goal was to set up a legislative background for pesticide use and mitigate the risks on human health and the environment. The Parliament and the Council started the discussions in 2006 as well. The current sustainable use of pesticides directive was implemented in 2009. In the 1940s, during the World War II. (WWII) Europe was faced with a huge shortage of food. The history of modern Plant Protection Products (further PPPs) started here. Land and crop care were getting more and more important around that time. From the 1970s the emphasis was placed on assuring sufficient food supply by considering health and environment protection.

Most of the time people believe that pesticides are dangerous materials in agriculture, which can affect their health and have negative impact on the environment. There is truth beyond the latter statements but these points of view are far from reality. Without pesticides the market wouldn’t be able to maintain the sufficient level of supply of the food and feed products. Therefore pesticides are necessary for plants. Thus PPPs have economic and environmental benefits as well. The application of pesticides can contribute to yield and sales growth for farmers. Due to hazardous circumstances such as fungi, insect or weed 50% of yields could have lost.⁶

---

⁵ See Appendix 3.
⁶ Internet source [7.]
Facts from the European Union

According to the Report of the European Union about agricultural statistics and economic information from 2012, some relevant tables are listed in the thesis to get an overview about inputs and the most common seeds.

Due to the fact, that this thesis is focuses on crop care and spraying application specifically in the Netherlands and Hungary, the only average values represented are these two countries as well as the EU average.

The farm structure has been changing around Europe. The numbers of farms which have an area with more than 50ha are growing. This trend has a key role in sustainable pesticide use because farms with more than 50ha are tending to invest in trailed or self-propelled sprayers. (Table of UAA\(^7\))

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm size class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>less than 5 ha</td>
<td>0,4</td>
<td>0,6</td>
<td>201</td>
<td>2,6</td>
<td>2,4</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-10ha</td>
<td>4,6</td>
<td>3,9</td>
<td>184</td>
<td>4,3</td>
<td>4</td>
<td>74</td>
<td>6,3</td>
<td>5,3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-20ha</td>
<td>6,1</td>
<td>5,7</td>
<td>269</td>
<td>9,6</td>
<td>8,4</td>
<td>157</td>
<td>8,1</td>
<td>7,4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-50ha</td>
<td>9,8</td>
<td>10,1</td>
<td>473</td>
<td>34,7</td>
<td>34,4</td>
<td>645</td>
<td>14,7</td>
<td>14,3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 50ha</td>
<td>71</td>
<td>74,3</td>
<td>3136</td>
<td>44,8</td>
<td>50,8</td>
<td>951</td>
<td>62,6</td>
<td>66,1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>4263</td>
<td></td>
<td></td>
<td></td>
<td>1873</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Utilized Agricultural Area for Hungary and the Netherlands
Source: www.ec.europa.eu\(^8\)

The Netherlands has an area of 41.528 km\(^2\). With the value of 7.750km\(^2\) almost 20% of the total area is water. The country has a leading position in productivity and intensity in the agro sector worldwide. Due to the amount of fertilizers, energy and PPPs that is used there is a huge difference in yields per a hectare between the two countries. In most cases the Netherlands has double productivity on crops such as wheat, cereals sugar beet and potato. The reason of this difference could be for instance the cultivation

\(^7\) Utilized Agricultural Area
\(^8\) Written source [6.]
technology, meteorological circumstances, or soil conditions but also crop care methodology.

<table>
<thead>
<tr>
<th>Country</th>
<th>Cultivated area/ crop (1000ha/2011)</th>
<th>Production (1000 t)</th>
<th>t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hungary</td>
<td>Netherlands</td>
<td>Hungary</td>
</tr>
<tr>
<td>Crop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wheat</td>
<td>980,5</td>
<td>151</td>
<td>4130</td>
</tr>
<tr>
<td>cereals</td>
<td>2747,9</td>
<td>208</td>
<td>10299</td>
</tr>
<tr>
<td>sugar beet</td>
<td>17,3</td>
<td>72,7</td>
<td>760</td>
</tr>
<tr>
<td>potato</td>
<td>22,1</td>
<td>150</td>
<td>488</td>
</tr>
<tr>
<td>Total</td>
<td>3768</td>
<td>582</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3: Utilized Agricultural Area for Hungary and the Netherlands**

Source: www.ec.europa.eu

In the report of the European Union from 2012, the farm inputs have been separated in six main categories. In the table below the latest data can be found about Hungary and the Netherlands regarding to farm input share. In the case of the Netherlands the fertilizers and crop care products together are responsible for 5% of the inputs. This value is 17% for Hungary.

<table>
<thead>
<tr>
<th>Inputs %</th>
<th>Seeds and reproductive areas</th>
<th>Energy and lubricant</th>
<th>Fertilizers and soil improvers</th>
<th>Crop protection products</th>
<th>Maintenance</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>8,3</td>
<td>14,7</td>
<td>2,8</td>
<td>2,5</td>
<td>4,3</td>
<td>67,4</td>
</tr>
<tr>
<td>Hungary</td>
<td>7</td>
<td>15,8</td>
<td>10,1</td>
<td>7</td>
<td>5</td>
<td>55,1</td>
</tr>
<tr>
<td>EU-27</td>
<td>4,7</td>
<td>12,1</td>
<td>7,8</td>
<td>4,4</td>
<td>5,6</td>
<td>82,3</td>
</tr>
</tbody>
</table>

**Figure 4: Farm input share in Hungary and the Netherlands (2011)**

Source: www.ec.europa.eu

---

9 Written source [6.]
10 Written source [6.]
The next graph represents the share of agricultural products in Hungary and The Netherlands compared to the EU 27 average. The Netherlands has a leading position in potato and vegetable cultivation. Hungary has a bigger role in wheat, barley and maize production. Milk and meat production gives the outlier value of other products in each country. Compared to the European Union, Hungary has higher share of maize and wheat in the national production than the EU average. The same statement is true for the Netherlands when referring to potato production.

![Figure 5: Share of agricultural products in total production (Hungary, Netherlands, EU-27, 2011)](source: www.ec.europa.eu)

Total input costs are increasing year by year. This results in more costs for farmers on crop care products. It is obvious that higher costs will enforce farmers to use the pesticides in a more sustainable way.

---

11 Written source [6.]
### Agricultural input costs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeds and planting stock</td>
<td>10221</td>
<td>11113</td>
<td>11019</td>
<td>8,7</td>
<td>0,8</td>
</tr>
<tr>
<td>Energy</td>
<td>25810</td>
<td>28779</td>
<td>30078</td>
<td>11,5</td>
<td>4,5</td>
</tr>
<tr>
<td>Fertilizers and soil improvements</td>
<td>14775</td>
<td>18660</td>
<td>19293</td>
<td>28,9</td>
<td>3,4</td>
</tr>
<tr>
<td>Plant protection products</td>
<td>10025</td>
<td>10557</td>
<td>10982</td>
<td>5,3</td>
<td>4</td>
</tr>
<tr>
<td>Sub total</td>
<td>60831</td>
<td>69109</td>
<td>71372</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>152060</td>
<td>169089</td>
<td>174866</td>
<td>Not relevant</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>212891</td>
<td>238198</td>
<td>246238</td>
<td>4,2</td>
<td>2,6</td>
</tr>
</tbody>
</table>

Figure 6: Input cost share in the European Union (2010-2012)
Source: ec.europa.eu

PPPs are one of the most essential materials in a farm business to assure yield steadiness and avoid infestations. On a sample holding below, a farmer has been using the following inputs on the cultivated crops and number of treatments. The most common used chemicals are the fungicides, and herbicides which have less negative impact on human health. Basically farmers do not invest in insecticides until it is necessary, because these products are more expensive.

![Crop and Input Costs](image)

Figure 7: Estimated input costs in total for a scenario farm
Source: Eric Teuwsen, Product Specialist at John Deere Fabriek Horst, www.agribenchmark.org

---

12 Written source [7.]
In total, pesticide application is responsible for almost 40% of input costs in this case. It can be easily stated that farmers really have to be careful with the application process and that the cost of pesticides is a key factor in a successful business. There is no farmer around the world who can afford unnecessary and non-returning investments, therefore it is really important to choose the most proper sprayer technology in order to avoid waste of money, time and crop care material as well.

Another key aspect to take into consideration is the number of treatments. Depending on the type of chemicals used, the more the treatments are, the higher the risk is. (See figure 8. above)

Assuring a food supply chain is impossible without professional crop care applications. PPPs can contribute to guaranteed yields, income for farmers and high quality of food worldwide. The challenge is in the sustainability, because the farmers are under double pressure. They have to supply the food chain and protect the environment at the same time. In this thesis the legal background of sustainable pesticide use and some other techniques will be introduced as a possible solution for farmers to deal with the challenges in the future.

---

13 Created by Teuwsen Eric, 2013
The Pesticides

The Plant Protection Products can be divided in three main categories:

- **Fungicides**: These chemicals have been used against fungus to hamper the fungi evolution or even to destroy them completely.

- **Herbicides**: The herbicides are being used against weed to destroy it completely or to roll it back.

- **Insecticides**: The insecticides can be also organic or inorganic materials. These are harmful on insects and pests.

The functional groups of chemicals are the following:

- Contact based chemicals are working only on the treated surface of the plant.

- Local systemic chemicals are working on the treated surface and on the nearby surface of the plant.

- Fully systemic chemicals are soaking the plant and working internally by treating the root system as well.

All plant protection products have a special active ingredient. The active ingredients are the real work horse for pest and disease control. This can be a chemical, or even a virus or a bacterium. In some cases these substances can be found in the food products as a residue in a certain quantity.

Fungicides and herbicides can be harmful on the environment but not on human health or only in very huge and unrealistic amount whereas insecticides can be harmful on the human health, so these chemicals are the most dangerous. After WWII, the DDT\textsuperscript{14} was the most common insecticide, but today it is forbidden to use.

In the European Union, the European Food Safety Authority is responsible to do the measurements on Plant Protection Products. Only the PPPs which do not have any environmental or human impact can be used within the EU.

The term residue refers to the amount of pesticide which sometimes remains on the surface of plants or crops. In the European Union it is prohibited to use any kind of

\textsuperscript{14} Dichlorodiphenyltrichloroethane – also known as DDT a very strong pesticide. It was used from 1950 in Europe. Because it’s harmful effect on the environment the use of DDT was banned in the 1960s. Hungary was one of the first countries to ban this product
pesticide until it receives its certification and approval which acknowledges that the current product has not got any harmful effects on customers, consumers, farmers, operators, and environment. After a pesticide was officially approved as a safe product; it will receive its special maximum residue level index (further MRL). These values are based on professional evaluation and laboratory work. The MRL is legally set amount of residue which permitted in food or feed stuff. The measures are in Mg of substance / kg of food. More than 60,000 PPPs are being tested annually in Europe. According to the evaluation reports 95% to 97% no measurable residues can be identified or the results are below the maximum levels. In cases of 3% to 5% the pesticides are not applied in a good order or special weather conditions have happened\textsuperscript{15}. 

\textsuperscript{15} Internet Source [5.]
3. **Legal Background of sustainable use of pesticides**

Besides Nitrogen and Phosphates, pesticides are one of the most dangerous polluters. Several directives in the European Union are related to the use of pesticides. These directives are also in connection with each other in order to give a common background for PPP use and for surface water protection as well.

![Legal elements of sustainable pesticide use](https://www.topps-life.org)

**Figure 9: Legal elements of sustainable pesticide use**

Source: www.topps-life.org


The originally implemented 91/414EEC directive says that PPPs can be placed on the market after an official validation only. This validation assures that the PPP does not have a harmful effect on human health and the environment. The list mentions all approved substances and is called the „positive list”.

The official European Union Pesticides Database provides information about the allowed active substances, toxicological information and Maximum Residue Levels in

---

16 Written source [12.]
17 Written source [15.]
food and feed products. The pesticides can be used on different kind of crops in the member states since they are approved to decide about the application individually.

On 14 June 2011 the previous directive was substituted by a new regulation 1107/2009\textsuperscript{18}. The difference compared to the preceding directive is that the regulation is obligatory in all member states within the EU.


The machinery directive was updated several times. The original 95/16/EC directive about machineries was updated in 2006. It covers personal health and safety, and domestic animal safety issues.

The latest directive (2009/127/EC) is an amendment of the 2006/42/EC stating that the requirements must be attached on the machines in order to protect the environment. These attachments provide information e.g. the filling and flushing, application rate, and maintenance. The design process of the sprayer has an important role to reduce and mitigate environmental and human risks.

3. *Sustainable use of pesticides (2009/128/EC)*\textsuperscript{20}

Within the four legal elements this directive is the most relevant. It came into force on 25\textsuperscript{th} of November, 2009. The member states had to apply the directive by 26\textsuperscript{th} of November 2011. The main goal of this directive is to reduce the above mentioned impacts and to propagate Integrated Pest Management and to introduce new technologies in spraying and non-chemical pesticides. The authorities of the member states have to implement their laws reacting on these goals and meet the specific requirements. The European Union has set the following key points for sustainable use of pesticides. One of the key points mentioned is that member states have to develop their own National Action Plan.

\textsuperscript{18} Written source [16.]
\textsuperscript{19} Written source [18.]
\textsuperscript{20} Written source [17.]
Stakeholders must take into account the article 5 to 15 drawn up in the directive. The articles are the following:
- Article 5: Training
- Article 6: Requirements for sales of pesticides
- Article 7: Information and awareness-raising
- Article 8: Inspection of equipment in use
- Article 9: Aerial spraying
- Article 10: Information to the public
- Article 11: Specific measures to protect the aquatic environment and drinking water
- Article 12: Reduction of pesticide use or risks in specific areas
- Article 13: Handling and storage of pesticides and treatment of their packaging and remnants
- Article 14: Integrated pest management
- Article 15: Indicators

4. **Water Framework Directive (WFD)**\(^{21}\)

Most of the EU member states have already implemented the 2000/60/EC water framework directive into the nation law. The main goal of this directive is to improve the natural water quality around the European Union. The final goal is to reach good quality of water by 2015. The WFD set the milestones which are have to be kept in order to achieve the goals for the third review session in 2027. The process was launched by a research in which authorities can be involved, with the source water locations and what the circumstances are. The process was continued by setting up a monitoring system and developing an activity plan for water sources. It means the best application technology, analysis results, measurement plan for further activities and a schedule for the checking.

The WFD covers additional directives such as groundwater protection (2006/118EC) or surface water protection (EQS directive environment quality standards). In Europe both surface and groundwater are being used for drinking water production. The drinking

\(^{21}\) Written source [19.]

15
water directive sets the maximum values for pesticides in 0, \text{1µg/l}. It equals with \text{1 g material diluted up in 10 million liter of water}. It means a zero tolerance against the concentration of pesticides in drinking water. If a pesticide concentration exceeds the maximum value of 0, \text{1 µg/l} the member states can limit or ban the use of it, and farmer might not have access to the proper pesticides for successful crop care activity.
4. Sustainable use of pesticides in the Netherlands and technological solutions

The Netherlands presented its own National Action Plan in November of 2012. This action plan describes step by step what kinds of measurements have to be done in the future for a more sustainable pesticide use. Netherlands always put the environment and its protection first. Because of the geographical situation there is a lot of surface water around the country. Due to the fact, the Dutch water management system is professional. The major aim of the action plan is to put more effort on environment protection and risk mitigation to meet the maximum values and the good water quality set by the WFD. These steps are not only about technology but correct operator behavior, training, and risk management as well\textsuperscript{22}.

For the coming period 2013-2023 the following proposed measurements will be applied. All of these measures somehow could be attached to surface water protection\textsuperscript{23}.

1. \textit{Promoting integrated crop protection}

Crop care treatments can be divided in several categories by their effects on the economy and ecology as well as on human health and environment. In the last couple of years, the Netherlands has spent a lot of money on integrated pest management to promote it for farmers by presentations, professional journals and trainings. In the coming years, the goal is to continue the already started process in the marketing of IPM methods, because by 2014 farmers have to apply the IPM principles. Stakeholders like distributors, growers and also the government will have a huge responsibility in the successful implementation of IPM. It should cover the financial solutions and consider the Common Agro-Policy measures.

\textsuperscript{22} Teuwsen Eric, 2013
\textsuperscript{23} Written source [5.]
2. **Producers of environmentally hazardous chemicals or harmful products have to supply emission mitigation plans**

The producers of crop care pesticides have a significant role in water pollution reduction to mitigate risks and emissions in order to reach the standards set in the WFD. The governmental sector also has to support these goals together with these producers. On areas where the pesticide application method and the emission value shows correlation, emission reduction plans has to be applied. The government has to evaluate the current water conditions and if necessary tune the monitoring system. Producers who have the right to certify and produce PPPs have to develop the reduction plans and supervise the implementation process. As a third aspect, people who have to use or apply potential harmful pesticides also have a key responsibility in risk mitigation.

3. **Waste water management in greenhouses from 2016**

Greenhouse cultures are always about intensity and efficiency. It is because of the calculable circumstances and controlled protection. Comparing the cultivation area to the arable farms, the environmental contamination by pesticides is much higher in greenhouses. New technologies will be applied in this sector to prevent further emission sources such as PPP application method and water purification systems.

4. **Safety zone enlargement**

The current minimum safety zone is 50 cm near the surface water. Within this crop specific safety distance no crop is allowed and it has to be strictly kept. For instance, when referring to the potato this 50 cm is compulsory unlike weeds. If the monitoring results of surface water do not attain the required quality improvements, this safety zone can be increased to 1 or even 1.5 meter from 2016. The safety zone enlargement has economic consequences as well. Farmers’ priority is to maximize the use of the available fields for growth; therefore cutting down the cultivatable areas can cause dissatisfaction and indignation in agribusiness.
5. Drift reduction regulation system in the Netherlands

Drift is a value of applied PPP which does not hit the target area in a good order and goes out from the field because of meteorological or other circumstances. Drifts can contribute to increase environmental pollution for instance in surface water. Buffer zones were developed in order to reduce the possibility of PPPs going into the water surface. Applying the most proper reduction technology, the buffer zones can be adjusted into narrower distances.

At the moment the value of drift reduction is minimum 50% on 14 meters besides the surface water. From the 1st of January 2014, the value of minimum drift reduction will increase to 75%. Measurements will be made till 2018. If the results will require more reduction, the minimum value could be even 90%. The buffer zone distances are country specific.

When a disease occurs on a plant, a specific chemical is recommended to treat it. In each country there is a responsible authority to approve and place pesticides on the market. An insecticide produced by Bayer CropScience is available to use in Germany and the Netherlands as well. To represent how the buffer zone adjustment works in practice, the following two tables will give the answer.

<table>
<thead>
<tr>
<th>Safety distance reduction in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of chemical</td>
</tr>
<tr>
<td>Crop</td>
</tr>
<tr>
<td>Drift reduction %</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>300 ml/ha</td>
</tr>
</tbody>
</table>

Figure 10: Safety distance reduction for DECIS EC insecticide in Germany

Source: Bayer Crop Science Germany

---

24 Written source [3.]
25 Based on Internet source: [2.]
Application of DECIS in Germany on Rape, Potato, Wheat

<table>
<thead>
<tr>
<th>Safety distance reduction in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of chemical</td>
</tr>
<tr>
<td>Crop</td>
</tr>
<tr>
<td>Drift Reduction %</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

*Figure 11: Safety distance reduction for DECIS EC insecticide in the Netherlands*

Source: Bayer Crop Science Netherlands  

Application of DECIS in the Netherlands on Maize, Potato and Broccoli

In the Netherlands, the previously mentioned crop free zone can also adjusted by using proper drift reduction equipment. It can be 150, 100 or 50 cm depending on the reduction capacity.  

a) *The technological background of drift reduction*  

This chapter is based on the official ISO standards of drift reduction measurements:

- “ISO 22866:2005 Equipment for crop protection – Methods for field measurement of spray drift”

This ISO standard gives information about the measurement of the drift reduction for a sprayer device. It sets the rules for the:

  - Selection of the trial site
  - Conduct of trial
  - Use of reference spraying system
  - Measurements of spray drifts
  - Replication of measurements

---

26 Based on Internet source [3.]
27 Internet source [9.]
28 Written source [9.]
- “ISO 22369-1 Crop protection equipment – Drift classification of spraying equipment”

This first amendment sets the drift classes of drift reduction. This compares the two devices and represents the drift reduction value in a percentage compared to each other.

<table>
<thead>
<tr>
<th>Class</th>
<th>F</th>
<th>E</th>
<th>D</th>
<th>C</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>25 - 50</td>
<td>50 - 75</td>
<td>75 - 90</td>
<td>90 - 95</td>
<td>95 - 99</td>
<td>99 -</td>
</tr>
</tbody>
</table>

*Figure 12: Drift classification of spraying equipment*

Source: International Organization for Standardization

For instance, if a nozzle has an F classification, it means the nozzle produces 25-50% less drift compared the reference nozzle.

- „ISO 22369-2 Classification of field crop sprayers by field measurements”

This second amendment contains the methodology of measuring different spraying devices on the field by setting up zones. There are 11 zones from 1 till 50m from the directly sprayed area. The purpose in this case is to compare the current equipment with the reference technology and define drift reduction capability as in the first amendment. This methodology could assure proper advice for stakeholders in crop care (farmers, manufacturers) in order to develop and use the best technology for specific farm conditions.

These three ISO standards are the fundamental brackets for the reduction technology. Those countries where the drift reduction regulation is already in use, the system was implemented from German agronomical practice. The JKI (Julius Kühn-Institut) developed a country specific drift reduction methodology. This institution is responsible

---

29 Written source [10.]
30 Written source [11.]
for publishing the approved technologies in Germany. This publication is being used in several other member states.

However the Dutch drift reduction methodology was basically copied from Germany; to this day the Netherlands has its own responsible institution to publish the approved drift reduction devices.

On the webpage of SDRT\textsuperscript{32} (Spray Drift Reduction Technology) more information is available about the member states, what is the current drift reduction methodology within a country.

There is no data available yet for the Eastern European countries. In general these countries are also implementing or copying the system of JKI. These countries have to take into consideration to develop the institutional background for the calibration and reference spraying technology nevertheless to set the crop and pesticide specific buffer zone system.

There were discussions about the idea to apply a minimum drift reduction on the whole field not only in the buffer zone, but it is surrounded by some concerns in the Netherlands. In general speaking these concerns are about the droplet size. The higher the droplet size is, the higher the drop off, whereas the lower the uptake rate is. Nevertheless the droplet goes through the soil surface into the ground water, which cause higher water quality deterioration.

In the last couple of years, drift reduction was the center of attention in the Netherlands however it is responsible for 10\% of surface water pollution in. The regulation of drift reduction is getting stricter in the country. There is a possibility that there was too much attention on that compared to machine handling and point sources. Chemical packages need to inform the operator on the drift reduction once applied the chemical to the field. The current reference is an 11003 nozzle with 3 bar pressure. All the further drift reduction measurements are compared to that nozzle.

Drift is when certain droplets - that also contain the active substances - do not make it to the target area. Drift can happen due to unexpected weather circumstances and operation failures.

\textsuperscript{32} Internet source [11.]
The main reasons are:33

**Droplet size:** The most responsible factor within spray application. The liquids will be discomposed to different sizes of droplets under pressure while the application is running. The smaller the nozzle size and higher the pressure, the smaller the droplets and higher the proportion of droplet driftage is.

**Height:** When increasing the distance between the target area and the boom the wind velocity will increasingly influence the driftage. The effect of wind speed can increase the amount of droplets that run off from the target area. It is prohibited to spray from a lower or higher height than was is recommended by the nozzle producer.

**Speed:** The increased operating speed can divert the droplets backwards. The droplets will get into turbulences and convection. It can also increase the chance of driftage. Generally known and accepted practice in the application is the 6-8 km/h speed. It is wise to slow down when the wind velocity is getting stronger.

**Wind:** This is one of the most relevant factors which can affect the drift. The higher the velocity, the higher the possible drift is. Due to the fact, that wind speed can be different during the daytime, it is important to select the most proper hours for the treatment. The nozzle manufacturers set the recommended pressure for all products. It is generally known that, when the wind speed does not reach a certain level (17 mph) the nozzles can be used on this previously set pressure. If the wind speed reaches this value, the spray pressure can be adjusted in order to produce bigger droplets for less drift. Over 5m/s wind speed it is not recommended to apply a spraying application.

**Temperature:** The surrounding temperature and the value of humidity can also affect the drift. If the temperature is higher than 25 Celsius, and the humidity is relatively low, small droplets will be produced which are able to drift more easily.

---

33 Internet source [12.]
Usually the most optimal time for the spraying application is in the early morning hours. The wind speed is below 5 m/s, the temperature is low and the humidity is also low. Chemical liquids are able to deposit on the plant surface in a relatively high concentration.

Further circumstances such as application pressure, application rate or even the nozzle size have a significant effect on the chemical drift as well. The drift can be managed successfully if the operator knows the machine and the influential circumstances. In case of every treatment, the operator has to find the balance between the settings and the efficient crop care activity. The above mentioned factors have to be taken into account for a safe and accurate spraying treatment.

The higher the drift reduction the more expensive the nozzle is. It means extra expenditures and costs for farmers, because they would like to reduce the buffer zone and grow as much crop as they can. Drift reduction has not only environmental but economic benefits too. By using air induction to the nozzles, the droplet size can be adjusted easily by reducing the amount of water. Moreover by using different kind of droplet sizes the applicable area can be increased, however it requires really accurate calculations before starting the actual treatment. Increasing the droplet sizes to coarse or

---

Internet source [12.]

Figure 13: Optimal weather conditions for sparing
Source: www.teejet.com[^34]
very coarse droplets could lead to higher run-offs. In this case the droplets will not adhere to the surface of the plant (on the leaf or on the root).

See appendix 1. to check a nozzle description as an example.

b) The edge nozzle

In the Netherlands using an edge nozzle is encouraged. This special type of nozzle can be attached to the end of the boom 20 cm from the last normal nozzle. In contrast with the normal nozzles, the edge nozzle has a special spray angle to contribute droplet drift onto water sources or other extremely sensitive areas. During the application besides the edge, the last normal nozzle has to be turned off and the edge nozzle has to be turned in. The edge nozzle must be turned off when the sprayer working across the field. The edge nozzle can be attached on all booms as well as on only one side. It is recommended when there is only one driving direction. On the following figure the working of the edge nozzle is represented.

![Figure 14: Setup of edge nozzle](WZ106117)

In Netherlands some of the described technologies are already in force. The safety and buffer zones, the edge nozzle, the storing requirements of the pesticides and the cleaning and maintenance requirements for the application machine lead a lot of extra expenses and energy for farmers. However as it is highly anticipated the environmental, technological and sustainability instructions will be even more unsparing. Regarding environmental protection, surface water protection and sustainable use of pesticides the similar regulations are in action in several member states like Denmark, United

---

35 Internet source [4.]
Kingdom, Germany or France. Differences can be found in maximum values, zone distances and application requirements but generally speaking the question of sustainability is on the table every day. Basically, in the Eastern European member states the regulations are not as developed or detailed as the Western countries. Due to the subsequent practice, the member states from Central and Eastern Europe have to prepare for the new legislation system.

c) Another approach

In the recent years another approach related to drift calibration and measurement has appeared.\textsuperscript{36} It takes the same inputs into the measurement but is based on a mathematic calculation. The current ISO system means a lot of effort, time and money for companies that are involved in crop care product development. When producers develop and launch a new product on the market, they have to make calibration every time to set the drift reduction value of the current product.

The other approach is forced by sprayer producers or other crop care equipment companies because this methodology uses a calculation which is more cost and time efficient.

6. Promoting activities in point source risk management. (Cleaning, filling, remnants)\textsuperscript{37}

Plant Protection Products and their remnants have to be stored in an impermeable storage room or container. The ground surface has to be non-inflammable, heat resistant and impervious.

In order to avoid leakages the storage room has to be equipped to collect the biggest possible content of chemicals (boxes, jar, and container). It is not allowed to spill remnants into water sources or sewers.

Sewerage remaining from machine cleaning is not allowed to spill out to local water sources or gutters either. Depending on local regulations, sewerage could be applied on non-growing areas.

\textsuperscript{36} Written source [8.]

\textsuperscript{37} Written source [1.]
Due to the fact that wrapping of pesticides is also registered as hazardous waste, packing also has to be treated. The treatment technology sets by the current product and its qualities. Users can bring back the unopened chemicals in the primary wrecking to the place of purchase. Products which have been opened have to be delivered to the local authorized waste processor location.

The European Crop Protection Association (ECPA) is representing the crop protection trade in a European level. The major assignment is to propagate new methods and technologies in the agribusiness and consider sustainability at the same time. Another assignment is to provide information about pesticide necessity and assure commitment to an efficient agribusiness and a good rate of living.

TOPPS (Train the Operator to Promote best Practices and Sustainability) which is a project within the European Crop Protection Association has developed an Environmentally Optimized Sprayer program for a more sustainable use of pesticides and reduction of surface water contamination. This project divides the potential contamination sources into two different categories.

- Point sources: filling, cleaning of the machine and remnant management
- Diffuse sources: run off, drainages, drift


---

<table>
<thead>
<tr>
<th>Source type</th>
<th>Risk area</th>
<th>% (Field crop sprayer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point</td>
<td>Inside cleaning</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Outside cleaning</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Filling</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Remnant management</td>
<td>15</td>
</tr>
<tr>
<td>Diffuse</td>
<td>Drift</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

**Figure 15: Point and diffuse source division in %**

Source: www.topps-life.org

In case of a field crop sprayer the above mentioned risk areas are responsible for water contamination in a certain percentage.

The program lasted three years, and several European countries were involved to the program. In the long run, the document of Best Management Practices was developed. It splits up the process in six different aspects:
- Transportation of PPPs
- Storage of PPPs
- Before application
- During application
- After application
- Waste and PPP remnant management

Nowadays the TOPPS has its own database, and most of the descriptions and recommendations are available in a wide variety of languages as well.

For point source risk mitigation the “Best Management Practices” can be a solution but to avoid misunderstandings these technologies are not especially Dutch ideas. These steps are not the only possible solution, they are just recommendations. However these practices are well known and used in a wide range around the Netherlands and getting more and more popular. To ensure the tendency of environmental thinking in the crop

---

Written source [12.]
care business, further marketing strategies and investments will be essential in the upcoming period as well. Hereinafter, some of the recommendations and technological requirements will be described which are currently used in the Netherlands\(^\text{40}\).

\textbf{a. Inside cleaning}

After the application there is always a remnant volume in the tank. The maximum remnant volume depends on the maximum tank capacity. It is recommended to clean the interior of the tank right on the field after the spraying work is done. For a sufficient tank rinsing, the following technical requirements have to be fulfilled.

- Rinse nozzle inside the tank
- Agitation of the remnant with clean water (rinse water tank min 10\% of the maximum tank volume)
- The agitated liquid can be applied on the treated area (10 times agitation for PPPs and 20 times agitation for herbicides)
- Also the cleaning of the outside surface of the machine is recommended to be done on the field after the application. By respecting the following steps, the surface water pollution can be mitigated.
- Clean the mud from the wheels and tires before leaving the field
- Pay attention to cleaning the boom and the backside of the tank. Most of the chemicals are deposited on these parts.
- Cleaning the machine on a yard has to be done on a special area, where the waste water can be collected.
- After the application, the sprayer has to be stored under cover.

\textbf{b. Filling}

The filling phase is significant because it is responsible for 20\% of risks of point sources. Two kinds of filling can be defined:

1) PPP filling

Chemicals and other liquid products can be filled into the sprayer by using a special chemical inductor. It is easily accessible from the ground floor and assures safety filling. With the rinse heads in the chemical inductor the whole chemical container can

\(^{40}\) Written source [12.]
be rinsed out. This step is really important; because if containers are not totally clean and empty they are deemed as point sources. This attached rinsing equipment is quite common in the Western European countries and less common in the Eastern and Southern European countries. Usually the sprayers are filled on the yard. Most of the times these areas are not planned to accumulate the sewage. Building this kind of special areas means a lot of investment for farmers and owners. Another solution could be to fill the tank directly before spraying on the farm. In this case the water and the PPP have to be delivered to the land too. There are sprayers designed to carry a clean water tank but only farmers with sufficient sized farms choose this way to fill the machine.

2) Clean water filling
The scales attached on the tanks are not always precise enough to measure the correct amount of water. After several uses the visibility of the level dwindles. Using imprecise technologies for water measurement can lead to liquid surplus in the tank. Improvement could lead to accurate calculations of water and using precise tank filling technologies (tank level indicators, overflow elimination, filling holes and calibrated scales). Filling could be done automatically, so that after a first tank calibration the computer would fill the tank accurately. This would avoid any surpluses and outside contamination.

c. Waste water management.
The biological purification technologies offer solution to handle the remnant water and pesticides on the farmyard. During the cleaning process, the biodegradable pesticides will go through an active substrate which contains microorganisms. Farmers can build these facilities themselves easily and operate them acting on the business circumstances. It is also important to mention that insufficient sizing and operation leads to less efficiency. Under good circumstances these equipment are able to clean the water with 95-99% efficacy.41

1) The “BIOBED” technology
The biobed technology is closely attached to the filling and cleaning phase of the machine. When the sprayer was cleaned on the treatment area and only non-applicable

41 Written source [21.]
remnants can be found in the tank, a biobed technology is recommended to use in order to eliminate the liquids. Thusly the purification rate will be higher together with a smaller biobed and lower operation costs. To prevent the run offs and leaching the biobed can be sunken under the ground level or placed on the ground. An active substrate which contains upper level soil and microorganisms and turf or straw will degrade the remnants.

Concrete or hard plastic can be used for the insulation. This is a closed system where leakage water will be collected and volatilized. For a quicker volatilization a glass cover is also recommended to use. The sprayers are often filled directly above the biobed to prevent leak off and reduce contamination risk. In some cases it is impossible to eliminate the whole amount of waste water because the biobed does not have a sufficient capacity. For an alternative solution a puffer container can collect and divide up the waste water depending on the capacity. A normally controlled, calibrated and used biobed lifecycle is around 6 up to 8 years. After this period it is wise to replace the active filter. This used filter can be distributed on the farmlands; however the legislation background of this is really short.

![Image](http://www.biobeds.org/User_files/L/02796559070aeced5c33820b700bf9196.jpg)

Picture 2: “BIOBED on the farmyard”

2) The “BIOFILTER” technology

---

42 [http://www.biobeds.org/User_files/L/02796559070aeced5c33820b700bf9196.jpg](http://www.biobeds.org/User_files/L/02796559070aeced5c33820b700bf9196.jpg)
The basic principles are similar to the ones that are applied at the biobed. Among others it is also important to clean the machine on treatment area and only the diluted remnant water is the only liquid allowed to fill onto the biofilter. The biofilter system consists of more containers and contains less active surface than the biobed and stored in the facilities around the farmland. The capacity of the biofilter can be increased by additional parallel containers. The construction process of biofilter systems is relatively simple since it does not require a lot of space; moreover it is cheap and flexible. The lifecycle is also the same as for the biobed. After 6-8 years the filter surface has to be renewed or replaced otherwise the capacity and the efficiency of the biofilter will not meet the required level of quality anymore.

Choosing the most suitable technology depends on several circumstances such as the size of the farm, the cultivated crops, the work of the operator and the condition of the sprayer machine. Considering these issues, the expected contamination can be calculated. Both the operator’s work and the advancement of the spraying equipment can contribute to the reduction of the surplus liquids as well as an increase in efficiency of the purification system.

![Picture 3: “BIOFILTER” system on a farmyard](www.topps-life.org)
7. **Further activities on personnel safety**

As well as in other member states, anybody who works with pesticides has to generally have a certification in the Netherlands. This certification can be acquired by a successful PPP management exam. Different types of certifications can be acquired due to roles and responsibilities. The current training system is working efficiently in the Netherlands. For non-professional users or advisors the certification is not obliged but they can also attend the courses individually. For less complicated operations with pesticides, it was not required to have a qualification. Nowadays stakeholders have to attend trainings at the place of work. The responsible office is the “Bureau Erkenningen” in the Netherlands. Training is a key in another aspect as well. It is not enough to have the latest features on a sprayer; it has to be operated in a good order. It is necessary to organize trainings about environmentally optimized sprayers and drift reduction technology. Private use of chemicals remains possible.

8. **Current spray license will be enhanced for farm owners**

Currently the spray license is valid for four years. In every four years the owners must renew the certification, otherwise they will lose the rights to buy, sell, apply or handle chemicals. If the farm owner is doing the spraying application personally, they must be certified and apply for a license card. Farmers who are hiring temporary operators are not obliged to have a license, but they have to hire certified operators only.

9. **Additional sprayers need to be tested and certified**

From 1997 and on, all the applied machineries and equipment need to have a recurrent audit to assure it is reliable, calibrated in an optimal way and is not hazardous for the operator, the environment and the people. From 2011 the audit process was extended to all other machinery categories. Knapsack and manual sprayers are still exceptions. In the Netherlands the Stichting Kwaliteitseisen Landbouwtechniek (SKL) office is primarily responsible for the management and the implementation of the audits. Due to the current regulation in every three years the machineries have to be audited. In some special cases the period could be six years, depending on the risk level of the equipment. The proper machinery condition also includes the features related to water
pollution. These are the hand wash tank, the rinse water tank and their capacity, the filling options, the inside rinsing technology, the nozzles attached on the boom, and the dilution system. The aforementioned features not only have to be indicated on the sprayer but also have to be calibrated, optimized and operated without any risk.

10. **Professional weed control on hard surface areas**

The Dutch government requires specific measurements for hard surfaces to be developed. Liquid chemicals are prone to leak into public wells and drains. It may cause a relatively high hazardous condition in drinking water quality. This step includes three different kinds of areas:

a. General public areas
b. Areas settled down in WFD, Birds Directive and Habitats directive
c. Recently treated areas

Additionally it will be prohibited to use agro chemicals on sport fields and recreation areas by 2018.

11. **The government should apply more control on obeying the rules. This step specifically covers fruit, greenhouse and bulb flower production.**

The Dutch government would like to have more control power and enforce farmers to observe the rules. It means that more employees will be hired by the government to do occasional supervisions on the aforementioned fields.

12. **Indicators: the HAIR2010 (Harmonized environmental indicators for pesticide risk)**

Firstly the HAIR software was created between 2004 and 2007. The idea was to compound the knowledge about possible environmental scenarios, emission rates, and pesticide effects to develop a European advisement system. In 2010 a second version of the HAIR was released by the Alterra Wageningen University. This update is much more user friendly and well developed. The software and user manual for the program can be downloaded from the website of HAIR 2010.
The Netherlands would like to use this program to draw up possible trends in the environment referring to pesticides. In order to gather more specific data, the HAIR 2010 will be expanded by the Dutch environmental indicator called NMI-3.*

In the coming period water protection is going to become more and more important, because it is essential for people these days, and it will be crucial for the future generation as well. The government of the Netherlands will prevent water surfaces of any value effacements set by the WFD. In any case of transgression special treatments are necessary to be applied that take polluters local circumstances into account.44

44 Internet source [8.]
5. What Hungary can apply from the Dutch NAP?^{45}

Since the early 1950s plant protection management has existed in Hungary. The first step was to develop plant care center system that gives coverage over the whole country. Also since the 1950s high level of education is available in plant protection. Later on, basic and intermediate education was also introduced in order to assure further possibilities in research and development.

In the next decade, the development of the advisory system focused on promoting the available technologies and gave advice for local farmers throughout the country.

After some successful laboratory experiences, the product called DDT was denied because of its negative effect on the environment. Hungary was one of the first countries that took this step.

In the 1970s, laboratories were established to analyze human, wild and water bodies. At the same time the use of fertilizers was getting more and more prevalent which spurred further activities in legislation and professional challenges. Since this time, the laboratories around the country have extended their activities from only getting plant protection tasks done to dealing with agro chemical measurements as well.

Due to the privatization wave after the regime change, most of the farmyards became private property and expanded to owners who had neither sufficient agricultural background nor crop care experience.

Hungary is an agricultural country. More than 80% of the available fields are capable of agricultural activity. The country’s meteorological circumstances are also prosperous moreover the soil conditions and its general productiveness are favorable.

Hungary released the national action plan on 26\textsuperscript{th} of November 2012. Contrary to the Dutch plan, Hungary’s first priority is the integrated crop protection, and development and implementation of new technologies in plant protection. The country has significant experiences in crop care and in water management as well, which is obviously the reason that Hungary has had the proper background of education on the field of plant protection since the early 1950s.

^{45} Written source [14.]
The structure of the Hungarian NAP can be divided in three categories.

a. Goals: what has to be achieved

b. Measurements: how to achieve the goals (I’d rather say “how to keep track of the processes”)

c. Indicators: How to evaluate the temporary results

The structure and the content are very clear and understandable. However in some cases it proposes only the needs to achieve a goal, but there are no concrete measurements about how to attain the target.

The Dutch measurements could provide solution in Hungary as well or at least support the development of strategy of sustainable pesticide usage. Even so these measurements are impossible to implement in practice until sufficient studies and evaluation have been done. These studies should take into account the unique climate atmosphere, the most common crop types, the machinery conditions and other major factors that can play a crucial role in the course of successful implementation. For example, to settle down the buffer zone distances and chemicals all of the mentioned factors have to be evaluated and express a common but easily acceptable strategy plan for farmers and stakeholders.

In Hungary, the proposal of the safety zone strategy will be faced with a serious opposition. Because of the trends in agricultural prices and uncertain annual yield income, farmers will not accept non-cultivated area on their fields. This safety zone regulation should be on hold until the infrastructure and other technological requirements are fulfilled.

First, farmers have to prepare for the new technological requirements on the spraying equipment in order of environmental protection. Purchasing new sprayers, and construct special cleaning areas for the sprayers creates a lot of extra costs for farmers that most of them probably cannot afford.

The practices developed by the TOPPS project are another kind of question. These practices do not always require further costs but can change the way of thinking and the operator’s behavior. Having respect for practices - in order to avoid point source pollution – some could contribute to mitigating risks in spraying application. The TOPPS practices are already available in Hungarian, the national agricultural institutions have to join forces and develop an efficient marketing strategy to make it
more popular and acceptable for farmers. This marketing plan should contain presentations, trainings, publishing brochures and other professional descriptions. The NAP mentions that special actions are needed in order to reduce point source pollution:

Regarding the previously mentioned drift reduction regulation the Eastern European countries still have to develop. These countries are up to date on technology but further action on the infrastructural background is needed if they would like to reach the same level as in the Western European countries.

Currently Hungary is copying the standard developed by the JKI. So far there is no responsible authority to manage the calibrations and set the standards for drift reduction. The specific environmental circumstances require the establishment of a special, optimal system in the future. The NAP has already mentioned the lack of measurements for specific and extremely sensitive areas:

According to the tendencies in the European Union, it is usual that measurements - applied in the Western European countries - are continuously adapted in the less advanced Eastern European countries. These countries such as Hungary have to prepare for the upcoming legislation process of sustainable pesticides and machinery.

It is notable that the market leader manufacturers like sprayer or nozzle producers in crop care division are developing their products in accordance with environmental friendly requirements. Certainly these devices are more expensive compared to the currently used and outmoded ones. In the future it is possible, that the current cross compliance requirements will be expanded by new technological requirements in order to receive subsidies form the European Union. A proper coverage will be necessary to assure satisfying information on the supporting possibilities for farmers. Loan advising and advisory system to find the best available possible solution for the farmyards is also recommendable.
Comparing the Hungarian NAP to the Dutch NAP

Integrated Crop Protection has a priority in the Hungarian NAP as well. One of the main goals is to describe ICP and propose measurements for the implementation.

Regarding to emission mitigations plans the Hungarian NAP does not contain relevant information. However this question can be solved in a national level and do not recommended following the Dutch proposal. As an alternative solution Hungary could use the Dutch ideas for the emission mitigation plans, but it requires more reviews and research.

For the waste water management in the greenhouses, the Hungarian plan also does not contain relevant information. The reason could be the relatively few numbers of greenhouses. The Dutch methodology could offer an alternative solution for Hungary in case of greenhouses. Since Hungary does not have any strategy for waste water management in greenhouses at all, it would be recommended to review and find possible way to implement the Dutch measurement.

Safety zone enlargement, drift reduction and source risk management was described already in more detail. These three elements are the most important for Hungary due to the lack measurements for these three issues. In the recommendation plan below, there are concrete ideas what Hungary should use from the Dutch system.

According to personnel safety, licenses and certificates, Hungary already has implemented measurements and these are working well. In these cases it not necessary to review the Dutch Plan because of the different local and legal conditions.

In Hungary the government has enough control on obeying the rules. However this could be expanded on fruit farms, greenhouses and bulb flower production as in the Dutch proposal.

The recommendation plan (figure 16) contains more information regarding to indicators.
Results

According to the statistical measurements in the first chapter the numbers of farms with more than 50 hectares are growing. Besides that, energy, fertilizer and crop care prices are growing. There is a huge gap in productivity between Hungary and the Netherlands. However farmers are trying to achieve the biggest possible yields year by year. Agricultural businesses have to assure the productivity jointly with environmental friendly solutions. There are several ways to reduce the input costs and protect the environment. The most relevant issues in sustainable pesticide use are point and diffuse risk mitigation. In Western European countries these solutions are widely accepted and used but in the Eastern European countries it is a quite new approach.

Discussion of the results

The results are representing that the farm structure in Europe is under a realignment process. The higher the farm size, the higher the input costs are. However to meet the global requirements farmers must these sources. By using labor work it would be impossible to produce enough food products for the food chain. Comparing the agricultural productivity of the Netherlands and Hungary, the Netherlands is more efficient. As discussed before the reason is the infrastructural background, the legislation and the innovative solutions. The Netherlands successfully tackled the sustainability question of pesticide use; however this country is still in a leading position of pesticide use. Hungary should follow this strategy in the future by taking into account the local conditions.

Some Western European countries for instance the Netherlands has proved the fact, it is possible to reduce pesticide use and do crop care activities in a more sustainable way. The only problem can be found in the question of droplet sizes. According to the interview with Eric Teuwsen (see Appendix 2.), an inappropriate drift reduction technology can lead to higher environmental contamination.
Because of lack of space and time this thesis could not answer all issues around this topic. In the future the following questions could be a main research question for reports or theses.

- Is it necessary to apply drift reduction on the whole field?
- How the crop care product manufacturers will react on the continuously occurring technological requirements?
- How the Eastern European countries will implement these kinds of measurements within a foreseeable time?
6. Conclusion and Recommendations

Conclusion

The continuously growing need for food and feed products requires a more precise and effective agricultural production. Meanwhile input costs such as energy, fertilizers, chemicals and fuel costs are also growing year by year. Farmers are facing with another issue which is sustainability and environmental protection. It is impossible to guarantee the sources for future generations without a sustainable way of thinking. Chemicals have key role in this issue, misuse or inappropriate use of them can lead to serious consequences.

In the Western European countries mainly Netherlands, Germany, United Kingdom and Denmark there are several measurements for sustainable pesticide use. These countries have a clear strategy to mitigate point and diffuse source risks, and to reduce spray drift. All member states of the European Union had to develop a National Action Plan for sustainable pesticide use. In this Plan, they have to describe the current situation and propose possible measurements in order to improve the sustainable pesticide use.

The Netherlands and Hungary were among the first states which have introduced the Action Plan before the deadline. Both countries have significant practice in agriculture, chemical use and water management. Regarding to some serious issues such as drift reduction, point and diffuse source management Hungary does not have a concrete proposed measurement only the need to develop it. The question is what Hungary could use and implement from the Dutch Action Plan.

As a recommendation Hungary should review and discuss the Dutch measurements for drift reduction, point source management and diffuse source management. By covering these problems, Hungary would be able to develop an effective Action Plan as the Netherlands.

Hungary as well as the Netherlands has a lot of surface water. It is obvious that Hungary must be responsible for water sources around the country. Regarding to point and diffuse source management it requires a lot of work but less capital. In the thesis several ways were introduced for risk mitigation for point and diffuse sources. In this case it is really important to change the operators and farmers behavior. Farmers could have the
best machinery, the latest technologies it does not matter if the application happens in a wrong order.

**Recommendations**

Comparing the two action plans is almost impossible since the two countries have different infrastructural background, weather conditions, farm structures and capital. Although there are many differences between the plans, there are some overlaps that can be found between them. This table gives recommendations from the Dutch methodology for Hungary in order to find a solution to achieve a goal. Of course these recommendations are not obligatory, but would be wise to take into account. This thesis was addressed for farmers, decision makers, experts and any stakeholders who are in connection with agribusiness, crop care, sustainability or chemical products. The recommendation plan could be interesting for all stakeholders. Everybody must be involved in the implementation. Farmers, Governmental representatives and other professionals must develop the country specific drift reduction strategy together; otherwise there will be always misunderstandings between the participants.

The figure 16 contains the recommendations for Hungary. The first three columns are cited from the Hungarian Action Plan. The title indicates the current topic, the objective indicates the goal what to achieve and the measurement indicates how to achieve the current objective. The recommendation column is coming from the Dutch Action Plan as a possible solution. In the stakeholder column all the target groups are represented. They could be linked directly to the current question.
<table>
<thead>
<tr>
<th>Title</th>
<th>Objective</th>
<th>Measurement</th>
<th>Recommendation</th>
<th>Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>“5.3.5 Introduction of Integrated Crop Protection techniques”</td>
<td>“Working out and disseminate an integrated production system which is uniform, provides high level of protection of health and the environment, and profitability, maintains the biological diversity and natural resources, as well as produces high quality healthy foods.”</td>
<td>“Optimal establishment and maintenance of protective vegetation bands at water coasts in order to prevent contamination caused by the use of PPP.”</td>
<td>Reviewing the Dutch drift reduction methodology Set up an official authority which can release the drift reduction equipment</td>
<td>Farmers, machinery and chemical producers, operators, Government and relevant institutions</td>
</tr>
<tr>
<td>“5.4.2 Reduction of environmental pollution caused by wastes of the remnants of not used PPPs and packaging materials”</td>
<td>“The objective is to actually increase the ratio of collected packaging materials, containers contaminated with plant protection products, as well as to eliminate the stocks of plant protection products eventually remaining at the agricultural producers and users of plant protection products, in a safe way for the environment.”</td>
<td>„Increased control of collection, transport and handling of packaging materials contaminated with PPPS, and of containers of PPPs and treated seeds as well as increased control of operation of waste management facilities and equipment.”</td>
<td>Promoting Best Management Practices of TOPPS in order to inform farmers about these steps and avoid point source contamination of the environment (presentations, introduction days)</td>
<td>Farmers, operators, TOPPS representatives The government should assure the sources to pay presentations, booklets, and any other additional materials to promote these solutions.</td>
</tr>
<tr>
<td>“5.6.2 Regulatory plant protection monitoring program”</td>
<td>“To mitigate environmental and human health risks posed by plant protection products, to perform targeted monitoring of active substances of the plant protection products and degradation products.”</td>
<td>“The environmental authority operates an Environmental Monitoring system to ensure the respect of environmental and water quality standards.”</td>
<td>Complemented with the 5.3.5 recommendations consider the special Hungarian circumstances in water surface and agricultural areas Reviewing the HAIR 2010 and make it acceptable in Hungary as well</td>
<td>National Inspectorate for Environment, Nature, and Water, Ministry of Rural Development, Environmental and Water Management agencies</td>
</tr>
</tbody>
</table>

Figure 16: recommendation plan for Hungary

Source: Based on the Hungarian Action Plan, made by the author

Besides that, it is really important for Hungary to follow the action plan in the future and do not neglect the implementation of it. Alternative solutions such as appropriate crop rotation, minimum tillage, hetero-cultures, or third generation pesticides could be possible to solve the issue of pesticides. Due to the fact there is not enough scientific information about third generation pesticides Hungary should follow the original recommendations for the moment. When enough significant information will be available about minimum tillage, Integrated Pest Management, or third generation pesticides, Hungary have to review and consider them as well. Until that the most important is the improvement of drift reduction, and point and diffuse source management.

---

46 These materials contains natural ingredients and do not have negative effects on the environment at all.
Bibliography

Written sources

1. BASF. Gyakorlati Vizvedelmi tanacskok a mezogazdasagban/Pratical suggestions for water protection in agribusiness


3. Dr. Jámbor Attila: The Future of the CAP.

   http://ec.europa.eu/agriculture/cap-post-2013/communication/slide-show_en.pdf (Downloaded: 24.05.13, Horst, Netherlands)

   http://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/docs/nap_netherlands_en.pdf (Downloaded: 27.05.13 Horst, Netherlands)


   Member States Factsheets – European Union, Update 2013, May
   http://ec.europa.eu/agriculture/statistics/factsheets/pdf/eu_en.pdf (Downloaded: 29.05.13, Horst, Netherlands)
   http://www.holsoft.nl/idefics/pdf/compag97.pdf (Downloaded: 28.06.213, Horst, Netherlands)

9. **International Organization for Standardization**, ISO 22866 Equipment for crop protection – Methods for field measurement of spray drift Switzerland, 2005


11. **International Organization for Standardization**, ISO 22369-2 Crop Protection Equipment Classifications of field crop sprayers by field measurements Switzerland, 2010

    (Downloaded on 26.05.13, Horst, Netherlands)

13. **Ministry of Rural Development**, Gazdalkodoi kezikonyv/Farmer’s manual
    Budapest, 2013
    http://www.nebih.gov.hu/szakteruletek/szakteruletek/rfi/kozerdeku_rfi/gazd_kez_ikonyv_rfi (Downloaded: 17.05.13, Horst, Netherlands)

    Budapest, 2012
    http://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/docs/nap_hungaria_en.pdf (Downloaded: 17.06.13 Horst, Netherlands)

   (Downloaded: 15.06.13, Horst, Netherlands)

   (Downloaded: 15.06.13, Horst, Netherlands)

   (Downloaded: 15.06.13, Horst, Netherlands)

   (Downloaded: 15.06.13, Horst, Netherlands)

20. **Teejet.** Drift Guard Flat Spray Tips  
   http://www.teejet.com/media/433202/013_cat51-m_lores.pdf  
   (Downloaded: 22.07.13, Horst, Netherlands)

21. **TOPPS.** Bio purification systems for spray remnants on farm  
   http://www.toppslife.org/sites/default/files/TOPPS%20brochure%20bio%20purification%20systems%20_comments_finally_0.pdf  
   (Downloaded: 25.05.13, Horst, Netherlands)
Internet sources

1. Official site of the Agri Benchmark, (Eric Teuwen)
   http://www.agribenchmark.org
   Retrieved on: 27.07.13

2. Official site of Bayer CropScience Germany, Product database:
   http://agrar.bayer.de/produktssuche.cms
   Retrieved on: 28.07.13

3. Official site of Bayer CropScience Netherlands, Product overview:
   http://www.bayercropscience.nl/bayer/cropscience/bcs_nl.nsf/id/Producten_Ove
   rzicht
   Retrieved on: 28.07.13

4. Edge nozzles, Deere & Company, 2013
   http://manuals.deere.com/omview/OMWZW13224_19/AG,WZ00009,119_19_2
   0060403.html
   Retrieved on: 12.05.13

5. Video made by the European Food Safety Authority:
   http://www.youtube.com/watch?v=u93BmEt2Vss
   Retrieved on: 19.06.13

6. Official site of the Europe 2020, general information:
   http://ec.europa.eu/europe2020/index_hu.htm
   Retrieved on: 01.08.2013

7. Official site of the European Crop Protection Association, What are pesticides:
   http://www.ecpa.eu/page/what-are-pesticides
   Retrieved on: 24.07.13

8. Official site of HAIR, Harmonised Envrionmental Indicators for Pesticide Risk
   http://www.hair.pesticidemodels.eu/home.shtml
   Retrieved on: 02.06.13

9. Official site of Helpdesk Water, List of drift reduction nozzles:
   http://www.helpdeskwater.nl/onderwerpen/emissiebeheer/landbouw-
   veeteelt/lotv/driftarme-doppen/@3575/lijst-driftarme/
   Retrieved on: 13.07.13
10. Official webpage of the JKI
   http://www.jki.bund.de/en
   Retrieved on: 12.07.13

11. Official site of Spray Drift Reduction Technology, The European Database:
    http://www.sdrt.info/
    Retrieved on: 28.05.13

12. Official site of Teejet, Tech support:
    Retrieved on: 21.06.13
List of Figures

Figure 1: Development of the Common Agricultural Policy

Figure 2: Utilized Agricultural Area for Hungary and the Netherlands ........................................6

Figure 3: Utilized Agricultural Area for Hungary and the Netherlands ........................................7

Figure 4: Farm input share in Hungary and the Netherlands (2011) ..............................................7

Figure 5: Share of agricultural products in total production (Hungary, Netherlands, EU-27, 2011) ..................................................................................................................................................8

Figure 6: Input cost share in the European Union (2010-2012) .......................................................9

Figure 7: Estimated input costs in total for a scenario farm .............................................................9

Figure 8: Number of treatments per a specific crop (estimated) ..................................................10

Figure 9: Legal elements of sustainable pesticide use .....................................................................13

Figure 10: Safety distance reduction for DECIS EC insecticide in Germany ..............................19

Figure 11: Safety distance reduction for DECIS EC insecticide in the Netherlands ..................20

Figure 12: Drift classification of spraying equipment (set by ISO) ..............................................21

Figure 13: Optimal weather conditions for sparing .......................................................................24

Figure 14: Setup of edge nozzle ......................................................................................................25

Figure 15: Point and diffuse source division in % .........................................................................28

Figure 16: Recommendation plan for Hungary ..............................................................................44
Appendices

- Appendix 1. Drift reduction Teejet nozzle description\(^{47}\) (www.teejet.com/products)

---

**DG TeeJet® Drift Guard Flat Spray Tips**

**Features:**
- Pre-orifice design produces larger droplets and reduces the small drift-promoting droplets, minimizing off-target spray contamination.
- Tapered edge flat spray pattern provides uniform coverage when adjacent nozzle patterns are overlapped in broadcast spraying.
- The color-coded pre-orifice is removable for any necessary cleaning operations.
- Available in both 60° and 110° spray angles with a durable stainless-steel orifice.
- Automatic spray alignment with ZSU12® NYR Quick TeeJet® cap andasket. Reference page 57 for more information.

<table>
<thead>
<tr>
<th>Size</th>
<th>0.25</th>
<th>0.30</th>
<th>0.35</th>
<th>0.40</th>
<th>0.50</th>
<th>0.60</th>
<th>0.75</th>
<th>1.00</th>
<th>1.25</th>
<th>1.50</th>
<th>1.75</th>
<th>2.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>90°</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60°</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110°</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Optimum Spray Height

- 60°: 75 cm
- 110°: 50 cm

How to order:
- Specify tip number: example: DG80002S - Stainless Steel with Kalflo® color-coding
- DG18002AP - Polymer with Wide color-coding

---

\(^{47}\)http://www.teejet.com/media/433202/013_cat51-m_lores.pdf
I have made an interview with Eric about pesticide use and sustainability. He has a very significant knowledge about the topic, and he had supported me with a lot of professional materials for my thesis work.

- **What is your general opinion about pesticides and sustainability?**
  “Using chemicals is more cost and time efficient than mechanical applications. Yields need to be increasing; it means a need for a more professional crop care application. Chemicals are essential in crop care in order to assure yield income and plant safety.”

- **What do you think about the trends, yield income and crops in Europe?**
  “Because of the regulation system around Europe, farmers have less availability of chemicals. The costs of approvals for chemicals are really expensive as well. In the other hand, the demand is increasing for food products worldwide. It requires the knowhow and the available best technology in agribusiness. Input costs are getting more and more expensive in the same time, farmers have to strain after good agricultural practices to avoid extra costs and waste”

- **What do you think about the proposed measurements for the Dutch Government?**
  “Legislation of pesticides will become stricter in the coming years. The reason why the whole process has started from the Netherlands is because the population/area ratio. Since 1995 the main goals are reducing chemicals and protect people and the environment. Nowadays there is more focus on alternative solutions. The government now is trying to have more control on pesticide use around the country.”

- **Do you agree with the measurements?**
  “Farmers are trying to spray with higher speed with lower amount of water and chemicals. Increasing the drift reduction up to 75% - 90% on the whole field will lead to higher resistance of pests and diseases. Higher droplets are tending to spring down from the leaves or the root and flow into the ground water surfaces.”

- **Would you like to recommend something additionally?**
  “Put more attention on point sources (filling, rinsing, and cleaning) rather than drift management.”
- What do you think about drift reduction?
“The basic approach is good. However instead of increasing the droplet sizes farmers should have to take into account the weather circumstances as well. These are wind speed, humidity, sunny or rainy conditions.”

- What is your opinion about point source risks?
“Drift is not only route to the surface water. At first time risk occurs when the operator opens the container. The operator behavior is a key factor in pesticide use. Good way of filling, rinsing and cleaning. Auto filling options on the sprayers can contribute to reduce risks.”

- What is your future vision about pesticide use?
“Training of operators is really important. Governments around Europe must focus on training programs to change the operator’s behavior. In the future farmers and institutions have to monitor the crops to measure resistance development.”

- How the environmental issues effect the crop care equipment manufacturers?
“Manufacturers have to use ISO standards as a reference. There are several available technologies on the market for instance boom tilt and height control, GPS section control and other automatic solutions to make spraying process easier for operators and farmers.”

- Anything else you would like to share?
“Spraying will stay the part of crop care, however it won’t become easier. (Legislation, requirements, integrated plant protection). It requires farmer support to assure enough information and money for a sufficient crop care business in the future.”

12.07.2013
Appendix 3. Main parts of an arable farm trailed sprayer (back view)

A; Tank, B; Wheels, C; Boom, D; Nozzles, E; Axle