Plant Protection: Risk precaution in dealing with endocrine disrupting pesticides demands shared responsibilities between actors of the whole agricultural system

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Abstract: *The widespread use of agrochemicals and its possible negative impacts on humans and the environment is still a highly topical and controversial issue. Of particular concern here are chemicals that can disturb an organism's hormone system. Referring to the precautionary principle, the objective of the research project start$_2$ (www.start-project.de) is to develop management strategies that helps reducing possible risks for humans and the environment by hormonally active agrochemicals. As empirical basis we interviewed farmers and initiated two expert dialogues. Our research findings underpin the well known fact that the use of agrochemicals is complex and dependent on more than the individual attitudes of the farmers. Agricultural plant protection management is a co-operative product of a complex agricultural system, which encompasses treatment, marketing, industry and agricultural consultation as well as the agricultural teaching institutions and the relevant scientific disciplines. Successful management strategies for risk reduction in the context of hormonally active agrochemicals thus need to involve all actors within this system. The paper presents a proposal for a strategy that promotes participation by enabling learning processes among these actors.*

Keywords: *plant protection, endocrine disruptors, agrarian sociology, system analyses, shared responsibility*

Introduction

Specialization and intensification of agricultural production still goes hand in hand with a growing use of chemical plant protection. A cost-effective and productive agricultural production is however confronted with risks for the environment and human health due to possible adverse effects of the pesticides used. Currently a critical discussion takes place that focuses on chemicals which may cause damages to an organism's health by affecting its hormone system. These endocrine disrupting substances are suspected of inducing disorders in the reproductive, thyroid, nervous, and immune systems of humans and animals (cf. Jobling et al. 2009). Aim of the transdisciplinary research project *start$_2$* is to develop long-term, precautionary strategies which in particular help to minimize risks for humans and the environment due to endocrine disrupting pesticides. To this end cooperative governance strategies are developed that integrate all relevant actors in terms of shared responsibilities. Key spheres of activity within these strategies are innovations in the development of environmentally friendly pesticides as well as targeted measures for the protection of water bodies. Of particular importance is, as a matter of course, the high input-oriented agricultural practice: What are–beyond banning individual substances and governmental regulation– measures for reducing application and emission rates that integrate into the complex daily routine of plant protection at the farms? This question was investigated by means of agro-sociological studies and the organization of expert-workshops.

Endocrine disrupting pesticides and their application in Germany

Bodies of the European Union, non-governmental organizations and scientific institutions tried in the past to identify and list plant protection products that have endocrine disrupting properties for humans and animals. A *start$_2$*-review of these lists revealed (Schulte-Oehlmann and Oehlmann,

forthcoming) that in Germany 41 out of 250 (16 percent) currently authorized active substances of pesticides were classified by at least one of the sources used as having endocrine disrupting properties.[1] In order to determine which of these substances is currently being used in agricultural practice, we evaluated the treatment recommendations of the plant health services (LTZ 2009; LLH 2009, bw-agrar 2009, Land& Forst 2008). The results are shown in Table 1. In the years 20082009 243 plant protection products have been recommended for agriculture. 35 percent of these were identified as containing one or more of the 41 active substances suspected of having endocrine disrupting properties. .

Table 1. Plant protection products with potentially endocrine disrupting properties

Fields of action	Number of recommended plant protection products according to LZT 2009, LVWO 2009, and LK-NRW 2009	Plant protection products with potentially endocrine disrupting properties	Percentage
Total	243	86	35 percent
dressing und granulate	26	17	65 percent
Herbicide	120	22	18 percent
Fungicide	59	39	64 percent
Insecticide	23	8	35 percent
Rodenticide	6	0	0
Molluscicide	5	0	0
Growth regulator	4	0	0

The issue of applying pesticides with potentially endocrine disrupting properties appears to be most relevant in cereal and potato cultivation (see Table 2. Here a significant use of fungicides with potentially endocrine disrupting properties occurs which are also often used in viticulture. In rape cultivation potentially endocrine disrupting insecticides play an important role.

Table 2. Plant protection products with potentially endocrine disrupting properties as used in different cultivations.

	Cultivated Crop	Number of plant protection products (number of active ingredients) with potentially endocrine disrupting properties	thereof:			
			Dressing	Herbicide	Fungicide	Insecticide
1	Cereals	43 (25)	8 (5)	10 (4)	20 (11)	5 (5)
2	Potatoes	22 (12)	2 (2)	3 (1)	11 (3)	6 (6)
3	Beet	9 (9)	3 (2)	none	4 (5)	2 (2)
4	Rape	11 (10)	2 (1)	1 (1)	2 (2)	6 (6)
5	Corn	7 (5)	2 (2)	5 (3)	none	none
6	Legume	2 (2)	1 (1)	1 (1)	none	none
7	Grassland	2 (2)	n/a	2 (2)	n/a	n/a
8	Viniculture	9 (6)	n/a	none	8 (5)	1 (1)

State of the art

The handling of pesticides in agriculture will–also because of recent and pertinent EU jurisdiction–increasingly become a significant public issue. Member States of the EU shall adopt National Action

[1] It is important to note that the studies which underlie the reviewed lists were not checked for their validity by Schulte-Oehlmann and Oehlmann (forthcoming). It is therefore possible that some substances falsely appear on the respective lists or that others are not included although there is evidence for endocrine disrupting properties.

Plans to set up strategies so as to reduce risks and impacts of the use of pesticides on human health and the environment. Nevertheless, there are to date only very few socio-scientific studies on this topic in Germany. If available, they are mostly constrained to reflections on the misconduct of farmers and the (quantitative) measurement of their attitudes. The starting point of these studies often is that a reduction of pesticides and environmental pollution could only be achieved by a change in the behavior and value settings of farmers. Therefore a large part of these studies is devoted to the detection of missing care, negligence and the legal and economic wrongdoing by farmers in their everyday use of pesticides (Umweltbundesamt 2006). In German-speaking research on plant protection the effects of the present, restrictive legal framework of the EU remains largely unstudied (e.g. effects of inspections, of the comprehensive documentation required in everyday work and especially of the method of operation applied in plant protection).

Studies on the application and handling of pesticides are carried out by environmental organizations such as the Pesticide Action Network and Greenpeace (Reuter 2007, Neumeister 2008). They concentrate on the impact of the use of pesticides on the environment and human health and on limit exceedances.

Relevant but limited inferences (on the basis of regional aspects and the sole consideration of specialized crop farms) for our investigation are provided by the EU project TOPPS (www.topps-life.org) which defines best farm management practices for reducing the entry of pesticides by point sources into water bodies (Landwirtschaftskammer Nordrhein-Westfalen n.d.). Unwanted pesticide depositions at farm level have been identified (Jensen and Spliid 2005). As key areas of activity the improvement of spraying techniques and of the farm plant protection infrastructure was identified (Jaeken / Debaer 2005).

US-American studies on specialized crop farms put the diverse work processes, the decision backgrounds and motives of farmers in the context of the application of pesticides (Moore / Villarejo 1998, Brodt et al. 2006). These investigations indicate that for farm managers plant protection is characterized by two conflicting objectives: spraying to insure against economic loss and not spraying to keep the costs of plant protection as low as possible. In addition, even though the decision to apply specific phytosanitary measures is made at farm level, the form and source of consultancy as well as the varying competences of the consultants appear to be crucial for the application of pesticides (Villarejo / Moore 1998). Moreover, as regards plant protection by farmers, three management styles can be differentiated: Environmental Stewards, Production Maximizers, and Networking Entrepreneurs. These styles were shown to have an influence on how plant protection is organized (Brodt et al. 2006).

Methodological basis of the study

It is still controversial, which of today's authorized pesticides are to be classified as having unwanted endocrine disrupting properties. For the empirical analysis the choice of production fields and corresponding farms as well as the interviews themselves thus had to be carried out with great care. To analyze today's practice of plant protection we decided to perform a qualitative study in which the farmers were explicitly approached as experts. Our questions focused on the specific on-farm requirements that nowadays exist for plant protection:

- How do farmers organize plant protection dependent on the different crops?
- How do the work processes look like? Which work steps pose particular challenges or difficulties?
- What factors, reasons and motives affect the way pesticides are applied?

Also the rather sensitive aspects of plant protection (e.g. the implementation of environmentally friendly practices and the proper disposal of pesticides) and the way how farmers deal with the existing governmental regulations (impact of inspections, documentation requirements in everyday plant protection and the handling of pesticides) were investigated.

The scope of the *start*$_2$ project made it necessary, to go beyond statements on the general value systems and judgments of farmers related to plant protection. There was a strong need to analyze plant protection as a comprehensive sphere of activity. Therefore, in a first interview phase we identified and discussed the seasonal successive working steps and points of decision-making by an open, episodic conversation. In this part of the interview it proved helpful to use subject related records such as field records and field or work diaries. In the second phase a guided interview was used to address specific questions on plant protection practice. These were e.g. questions about the implementation of best practice in the field, dealing with today's control instruments, spraying technologies, the on-farm organization of plant protection, labor- and health protection and the different kinds of consultancy and information flow. The final topic of the interview was the issue of unwanted endocrine disrupting properties of pesticides in use.

Sample

In this investigation corn-growing farms received priority: In Germany 70 percent of the total acreage is used for crop production; of which more than half is used for cereal-growing. Moreover, in terms of the consumption of plant protection products cereal-growing is considered to have a high uptake rate. And, finally, a wide range of active substances with potentially endocrine disrupting properties is used in this area. The beet and rape production was taken into account, because it is an important element of the crop-rotation in cereal farming. Potato production in Germany no more takes much arable land but is characterized by an intensive application of pesticides. Here the variety of pesticides with endocrine disrupting properties appears to be considerably smaller but–measured in total inland consumption–significant amounts of them are used. Maize cultivation and grassland management were also taken into account in order to indirectly cover also cattle keeping farms with the study. Viniculture was chosen as an example for specialized crops.

Finally we selected a study sample of 13 farms. The sample was not intended to represent the complete spectrum of farms and production areas in a down-scaled picture (cf. Rosenthal 2005) but a wide variation of farm types. For the study we chose those regions in Germany which are typical for the production sectors we were interested in (northern, southern and central Germany). The selected farms had between 16 and around 1.000 hectares of arable land. This extreme difference in the size of the farms was accompanied by strong differences in farm organization (family farm, sole proprietorships, affiliated groups, cooperating business). Some of the companies built professional machinery cooperation’s to manage plant protection.

The survey was complemented by two expert-dialogs with representatives from the agricultural practice, organizations and authorities. Thematically, these workshops focused on innovative plant protection technologies and the discussion of the project results, respectively.

Results

Our results of the interviews and the expert workshops show that there is hardly any awareness of and knowledge about the problem of endocrine substances in plant production products. Therefore we focused on the more general risks of farmers pesticide use to derive from that special risk management strategies for endocrine disrupting pesticides. Looked at this way, endocrine disrupting pesticides a just an example for hazardous pesticides.

Agricultural management is influenced by a wide variety of internal and external factors and that plant protection (especially on the intensively crop-producing farms) takes place in a very narrow operational framework with only few options (cf. Fink-Kessler / Jürgens 2009a). Conventional agriculture nowadays basically works with chemical pesticides. To safeguard highest yields plant protection cannot be dispensed with. Highly specialized farms operate with an intensive und standardized pest management. At the same time the handling of plant protection means coping with great complexity and dynamics. The form and extent of standard treatments in plant protection

is influenced by a large number of aspects. As regards the particular farm types investigated current practice in plant protection can be described as follows:

- Each of the interviewed farm managers practices a fixed seasonal treatment with successive phytosanitary measures as standard (e.g. dressing seeds, weed control, stalk shortening, first and second fungicide spraying). To avoid economic risks by losses of yields and quality, farmers cannot go below this standard. This sequence of action varies depending on the various crops produced on the farms – a practice also clearly recommended by the consulting services and science. Plant protection can both be protective, i.e. precautionary, as well as location-specific and curative.
- Numerous internal and external factors lead to variations from these routine activities. Among these are
    - the management of pesticides, i.e. the change of active substances (e.g. to avoid resistances), application rate, mixtures of pesticides and the timing of the spraying, use of IPM-practices.
    - the economic importance of crop production, the farm structure, crop rotation, selection of seed, types of tillage, etc.
    - the working pressure, farm size and individual skills and interests

Concerning form and extent of plant protection crop production is central due to its general economic importance (cash crops or feed grain). It determines the cultivation practice and thereby the expenses for pesticides and the intensity and extent of the treatments. Central “set screws” as regards extent and intensity of plant protection are again the selection of seeds, the type of soil cultivation and the management of the crop rotation. Fields of activity concerning the reduction of pesticides therefore depend on the grade of farm specialization and consequently on the specific options farms have in the field of “sustainable” cultivation techniques (tillage, crop rotation, choice of cultivar).

We can roughly divide our farm sample into two categories: Those which are practicing an intensive crop production and others which prefer extensive crop production. On extensively producing farms the potential of reducing chemical plant protection is realized by means of the cultivation praxis, i.e. by the utilization of “sustainable cultivation techniques”.

In particular, this means choosing a “wide” crop rotation, practicing mechanical soil cultivation and selecting resistant cultivars. Intensively producing farms have only very small reduction potentials which are restricted to “managing” the different pesticides and improving the spraying technologies. Sustainable cultivation techniques could offer reduction potentials also for intensively producing crop farms. They are, however, hardly applied today.

It generally holds true that the higher the expectations on earnings in crop production, the more intensive is the chemical plant protection. The cultivation of high-yield varieties requires large amounts of fertilizer and puts high demands on plant protection. In this case the utilization of sustainable cultivation techniques is limited because of the strong specialization in crop production. Farmers try to balance the emerging problems of the “narrow” crop rotation through chemical plant protection, advanced spraying technologies and the management of chemical agents and resistances.

Industrial Engineering / Influence of experts systems

According to the interviewed farmers industrial engineering has a considerable impact on the generally increased intensity of phytosanitary treatments. If the working pressure increases, farmers revert to quick and safe “standard treatments” rather than checking their fields for possible infestations. As responsible for the increased intensity of treatments in plant protection the farmers consider the increase in farm-sizes (cf. also Hommel / Deike 2009:57). As another cause for the high

working pressure they mention the obligation to document the expenses of plant protection products: In their view valuable time which could be used for rating and field commissions. Finally, area-specific treatments are rare due to automation and long distances between fields.

The plant protection strategies of farms (the "inside") are also influenced by different expert systems and frameworks (the "outside"). Here are some examples:

- official agricultural advisory services, agricultural trade, agribusiness and trade magazines use standard, one-way methods of counseling (information telecopies, handling instructions, recommendations for applications rates,; in addition their pesticide treatment recommendations tend to cover larger regions;
- private consulting agencies in contrast turn to discursive practices to advise the farmers; they discuss individual treatment steps with the farmers in the fields and also point to possible pesticide savings;
- consultants and scientists communicate knowledge of the "traditional agricultural science" to practice (including knowledge on phytopathology, agricultural engineering, soil science, plant production and breeding);
- the fulfillment of obligations under cross-compliance, i.e. a good and accurate documentation of the use of pesticides, is more important for the farmers, than independent action for environmental protection (i.e. biological pest control management);
- farmers, who participate in agri-environmental and contractually based programs for water protection and conservation, reduce the use of pesticides in specific areas;
- cultivation practices and consequently the use of pesticides are influenced by the market and by contracts with fabricators and distributors.

Shared responsibilities as a way to reduce risks of pesticide use

How can we achieve social and technological changes that help strengthening precaution in dealing with risks due to the use of pesticides? On the basis of our empirical investigations we conclude that first of all a common understanding of the complex interactions between the specific operative, economic, social, legal, political and ecological impacts and processes has to be developed. We then consider the responsibility of all and the pursuit of common interests as a promising starting point for action and for the implementation of measures for risk reduction.

The responsibility of all and in particular of the "agricultural system" (i.e. agricultural science, policy, counseling, fabricators, industry and also consumers) must be recognized. Otherwise the farmers will experience the issue of further reducing risks due to the use of pesticides as an external claim, forced upon them “by others” and “by the outside”. Problems of acceptance thus have to be expected. Instead, common concerns of agriculture and society need to be defined. For example:

- The preservation of soil fertility / profitability: this objective is closely associated with the use of "sustainable cultivation techniques”. and results in reduction potentials for pesticides.
- The reduction in operating costs, e.g. the costs of energy and fertilizers (nitrogen, potash and phosphor fertilizer). This objective is relevant for farmers in economical terms and touches upon important social concerns (e.g. energy savings and reduction of CO_2-emissions).

A methodological rethink: teams of experts for regional and joint action

A reduction of pesticides (with endocrine disrupting properties) can only be achieved if all stakeholders feel involved and addressed. Successful and fair co-operation means abandoning the position that farms are the single cause for negative environmental effects and pesticide problems. This means addressing not only the operative basis of the farmers but also the entire agricultural expert system, when it comes to designing and developing measures for the reduction of pesticide use in specific areas.

Required are not only the provision of direct advice and improved information, but, most importantly, the establishment of cooperative strategies for action and of common learning and implementation processes. These processes should be organized within regional or area-specific working groups and should be based on the real problems occurring in everyday agricultural practice. In such "expert teams" farmers and representatives from the agrochemical industry, agricultural administration and educational institutions, agricultural consultancy and policy need to closely cooperate. They must be prepared to find solutions even under conditions of conflict and together with different environmental groups (water and nature protection groups). By this means competing or conflicting perspectives on plant protection can be transferred into joint approaches. The expert-team approach should be tested in "hot spot" regions and should be organized in close cooperation with local agricultural and environmental actors.

In Table 3 and 4 catalogues of measures designed to help strengthening precaution in dealing with environmental and human health risks due to the use of (endocrine disrupting) pesticides are presented. There are different levels and starting points for reducing or avoiding risks of these pesticides. Table 3 and 4 give examples. One of our key starting points is the promotion of a change in the operational focus and in the cultivation techniques. The measures themselves should be implemented within and through the mentioned teams of experts for regional and joint action.

Table 3. Measures for strengthening risk precaution in chemical plant protection

Measure	Specification
Exchange of training concepts and best practice in the field of pesticide use and plant protection	Sustainable methods of plant production and plant protection Information about pesticides with specific risks Environmentally aware handling of pesticides
Area specific solutions for goal conflicts between water and soil protection and the reduction of pesticide use	Calculate the risks of conservation tillage in regard to advancing the use of specific (e.g. hormonally active) pesticides Abolishment of the regulations of conservation tillage, required by cross compliance in the context of areas endangered by erosion (C1-C3 categories)**.** Transfer the decision about culitvation techniques to regional expert teams
identification of best practice farms with a low pesticide input pest management	Sustainable cultivation techniques, integration of non chemical methods Minimal pesticide use Integration of low-input-strategies and/or organic farming principles
independent information and consultancy about hazards and specific risks associated with pesticide use	Promote independent services for professional users with the focus on environmental and human health risks of pesticides (information letters, internet services)
Voluntary pesticide reduction programs and contracts	Use of existing cooperation and agricultural voluntary programs (water protection contracts, agri-environmental programs of the EU) Development of site-related voluntary contracts and necessary information and consultancy services Implementation of area specific pesticide analyses in water, soil and sewage treatment plants and feedback of the findings to the farmers
Analytical determination of hot-spot-areas with respect to endocrine disrupting pesticides	Use of appropriate analyses developed in the context of the National Action Plans (models to monitor the use of pesticides and specific pesticide substances) Development of substitution strategies

Table 4. Measures for strengthening risk precaution in chemical plant protection.

Measure	Specification
Simple and inexpensive technologies for pesticide application	Low budget variants, pesticides application equipment for small-scale regions, technologies to improve the cleaning of the sprayer and to facilitate the disposing of empty packaging and other contaminated materials Dissemination of soft electron treatment, combined with analysis of seed on pathogens Establishment and further development of technical methods of plant protection from organic farming Further development of packaging for a better handling and to minimize pollutions from point sources
Improving the recycling system	Extension of deadlines, improvement of the organization and delivery technology, establishment of permanent return facilities at recycling centers

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