Science of the Total Environment 575 (2017) 152–161

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Lack of evidence for a decrease in synthetic pesticide use on the main arable crops in France

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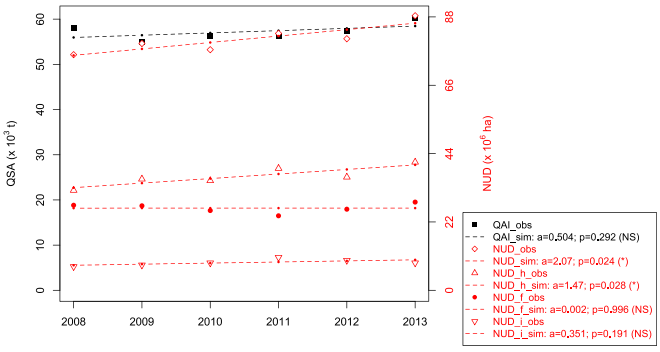
HIGHLIGHTS

- Trends in pesticide use on arable crops in France between 2001 and 2014 were described.
- No change in pesticide sales was observed at the national scale.
- Pesticide use has not decreased more rapidly since the adoption of the environmental plan.
- Water pollution did not decrease.

GRAPHICAL ABSTRACT



Pesticide use trends shown by the national indicators quantity of active ingredients (QAI, in black), number of unit doses (NUD, red diamonds), and number of unit doses for herbicides (NUD_h, red upward triangles), fungicides (NUD_f, red dots) and insecticides (NUD_i, red downward triangles) for the total surface area under agriculture in France. Dashed lines indicate the fitted regressions.

ARTICLE INFO

Article history:
Received 15 June 2016
Received in revised form 1 October 2016
Accepted 1 October 2016
Available online 10 October 2016

Editor: D. Barcelo

Keywords:
Agricultural policy
Pesticide indicators
Crop
Impact
Water pollution

ABSTRACT

The frequent, widespread use of pesticides in agriculture adversely affects biodiversity, human health, and water quality. In 2008, the French government adopted an environmental policy plan, "Ecophyto 2018", to halve pesticide use within 10 years. Trends in synthetic pesticide sales and use in France were described, through three different indicators: the number of unit doses (NUD), the quantity of active ingredient (QAI), and the treatment frequency index (TFI). Changes in pesticide use on seven of the principal arable crops in France since the implementation of this policy plan were analyzed, together with the impact of changes in pesticide use on water quality. No evidence was found for a decrease in pesticide sales at national level between 2008 and 2013. In terms of the TFI values for individual crops, the only decrease in pesticide use observed since 2001 was for soft wheat. This decrease was very slight, and pesticide use did not decline more rapidly after 2006 than before. Changes in pesticide use differed between French regions and crops. Water pollution did not decrease during the period studied. Possible explanations for the lack of effectiveness of the French environmental plan are considered in the context of European legislation.

1. Introduction

Europe has been the leading consumer of synthetic pesticides worldwide since 2004 (based on pesticide sales; McDougall, 2013), accounting for about 45% of total pesticide use (calculated by weight; De et al.,

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http://dx.doi.org/10.1016/j.scitotenv.2016.10.008
0048-9697/

2014). In France, agriculture uses an average of 4.1 t of active ingredients per 1000 ha per year, close to the European (EU-15) average of 5.1 t (Eurostat, 2014). This intensive use of synthetic pesticides has serious consequences for the environment and human health (e.g., Elbaz et al., 2009; INSERM, 2013). Several common pesticides were classified as 'probable' or 'possible' carcinogenic by international agencies (i.e., glyphosate in 2015 (IARC, 2016) and metolachlor in 1998 (EPA, 2016), respectively). Pesticides can contaminate surface water through leaching (e.g., Gilliom, 2007), with deleterious effects on non-target organisms, such as fish populations (e.g., Carriger and Rand, 2008; Shinn et al., 2015). Intensive pesticide use also generates costs associated with the treatment of pesticide damage, and these costs may be high enough to drive associated total costs beyond benefits (Bourguet and Guillemaud, 2016).

Synthetic pesticides have been detected in 93% of French watercourses (SoeS, 2013). In 2011, pesticide concentrations exceeded the limit allowed for drinking water (0.5 μg l^{-1} in Council Directive 98/83/EC, 1998) in about 4% of groundwater and 30% of rivers (SoeS, 2013). Water containing >5 μg l^{-1} pesticides cannot legally be used to produce drinking water in Europe, and water containing between 0.5 and 5 μg l^{-1} pesticides must be treated before use (Council Directive 98/83/EC, 1998). Every year in France, about 45% of the volume withdrawn for drinking water is treated to remove pesticides (Bommelaer and Devaux, 2011). The spatial distribution of pesticide-contaminated water is uneven over France, with higher levels of contamination for agricultural zones specializing in cereal production and vineyards (SoeS, 2015). The cost of eliminating 1 kg of pesticide from water ranges from €60,000 to €200,000 (Bommelaer and Devaux, 2011). The extra processing costs for drinking water due to pesticide contamination have been estimated at between 260 and 360 M€ annually in France (Bommelaer and Devaux, 2011). These costs are of a similar magnitude to the 120–360 M€ estimated for nitrate treatment each year (Bommelaer and Devaux, 2011). Between 1998 and 2008, 372 French water catchments were abandoned due to high levels of pesticide concentration (State Secretariat for Health, 2012).

In 2009, the European Parliament established a framework to "achieve the sustainable use of pesticides" through Directive 2009/128/EC (2009). According to this directive, each Member State is required to adopt a national action plan laying down quantitative objectives, indicators, and a schedule to "reduce risks and impacts of pesticide use on human health and the environment". The general objectives of this directive include (1) promoting integrated pest management (IPM) and the use of alternative techniques, to limit pesticide applications, (2) monitoring the use of plant protection products and setting targets for its reduction, and (3) training and informing professional users and the general public, and raising awareness about the hazards and risks associated with pesticides (Directive 2009/128/EC, 2009).

France adopted an ambitious environmental policy, including quantitative objectives in 2008, to comply with this directive. This environmental policy, "Ecophyto 2018", was designed to halve agricultural and non-agricultural pesticide use within 10 years, but included no mid-term objective. This policy included four main actions designed to promote changes in the behavior of farmers in terms of pesticide use. One of these actions was the provision of better information for farmers concerning the real threats posed to crops, through the reinforcement of pest surveillance networks. Another focused on the identification and promotion of agricultural practices less dependent on pesticides (IPM, biocontrol), notably through the support of innovations in crop management practices and the development of cropping systems with lower levels of pesticide input. The third action was the establishment of a network of experimental farms. These farms were intended to have a pedagogical role, showing farmers how to achieve good results by using pesticides differently or at lower doses. The training of agricultural professionals in the safe use of smaller amounts of pesticides was also planned (Plan Ecophyto 2018, 2008). In addition to Ecophyto 2018, some pesticides with particularly dangerous active ingredients were banned. Substantial investment was dedicated to the Ecophyto 2018 plan, with an average annual budget of €100 million for the 2010–2012 period (Commission des affaires économiques sur le projet de loi de finances pour 2013, 2012). This funding comes from three main sources: the French State (€130 million for the 2010–2012 period), a Pigovian tax ("fee for diffuse pollution"; €150 million for the 2010–2012 period), and other public institutions, including the European Union (Commission des affaires économiques sur le projet de loi de finances pour 2013, 2012). The Pigovian tax for pollution (Law no. 2006-1772, 2006) was initiated in January 2008, and is based on the "polluter pays" principle. Substances containing active pesticides are taxed according to their level of toxicity, and pesticide distributors pay these taxes.

This study provides a detailed compilation and analysis of data for pesticide use and water quality in France. It also aims to assess the mid-term effects of the Ecophyto 2018 plan. It focuses on synthetic pesticides for agricultural use, which accounted for 88–93% of pesticide sales from 2008 through 2013 (calculations based on Ecophyto-Note de suivi 2014, 2015). Official French data on pesticide sales and use, and on water quality, between 2001 and 2014, were obtained.

2. Materials and methods

2.1. Indicators of pesticide use

This analysis was based on the three indicators selected by the French Ministry of Agriculture for the monitoring of pesticide sales and use at the national scale and for evaluations of the impact of its environmental policy (Plan Ecophyto 2018, 2008). These indicators include only synthetic pesticides and do not take biocides into account.

The first indicator is based on yearly pesticide sales at national level: the number of unit doses (NUD) per hectare. The NUD is an indicator created to monitor trends in pesticide use following the implementation of Ecophyto 2018. As the official indicator for the assessment of the Ecophyto 2018 plan, it was designed to prevent an artificial reduction of sales figures linked to the replacement of one active ingredient by another ingredient effective at a lower dose (Ecophyto-Le NODU, 2012). NUD is the total number of treatments performed annually on all the agricultural land throughout France. Its division by the total acreage of agricultural land (accessed in Agreste, 2016), yields to the mean number of treatments per hectare of agricultural land. The NUD characterizes the annual intensity of pesticide use, based on the total amounts of active ingredients sold, national crop acreages and the crop-specific doses recommended for each active ingredient (Fig. 1). Firstly, for each crop and each active ingredient, a specific "unit dose" is determined from the maximum dose recommended for the crop and active ingredient considered. Secondly, a unique unit dose is defined for each active ingredient, by weighting the crop-specific unit dose by crop acreage. Thirdly, the NUD is calculated by summing, for all active ingredients, the amount of active ingredients sold, divided by their previously defined unique unit dose (Fig. 1). The NUD was calculated for all types of synthetic pesticides together (total NUD) and for individual types of pesticide (fungicides, herbicides and insecticides). NUD data were reported for each year between 2008 and 2013, in the annual reports on pesticide use of the French Ministry of Agriculture (Ecophyto-Note de suivi 2014, 2015). The Ministry made use of a national database to calculate the NUD, assuming that all the products purchased were used in same year. This database was compiled from sales balance sheets transmitted by pesticide dealers to state agencies and water offices, as part of their mandatory statements on diffuse pollution for calculation of the Pigovian tax (Ecophyto-Note de suivi 2014, 2015).