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Prevention of Water Contamination from Pesticides: the TOPPS Project BMP Dissemination in Italy

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Improper use of pesticides and unfavourable weather conditions in agriculture may cause either point or diffuse sources that can severely contaminate surface water. According to several studies carried out especially in Northern Europe, majority of risks are linked to point sources, that are mainly generated during the filling and cleaning of sprayers and are also related to the practices adopted for remnants management at the end of spray application. Between 2005 and 2008 EU-Life and ECPA (European Crop Protection Association) funded a project named TOPPS (Training of Operators to prevent Pollution from Point Sources) that was carried out in 15 EU countries and was aimed at defining and disseminating common Best Management Practices (BMP) to prevent point sources, considering the six phases covering transport of PPP, storage of PPP, spray mixture preparation and filling of sprayer, spray application, cleaning of sprayer and disposal of remnants of the spray mixture.
Starting from February 2011, ECPA funded a second project regarding diffuse sources, mainly related to run-off / erosion and to spray drift. The project is named TOPPS-PROWADIS (Train Operators and Promote best Practices and Sustainability – PROtect Water from Diffuse Sources) and involved 7 European countries. Scope of the project has been to develop EU harmonized Best Management Practices to mitigate risks of water contamination due to pesticide run-off and to spray drift and to disseminate them also through training activities and information materials. These activities are in line with the contents of EU Directive on sustainable use of pesticides (128/2009/EC) and were developed by two separate teams (one for drift and the other for run-off) established within the project.
On the basis of the work carried out, a complete framework of Best Management Practices, 117 to prevent point sources and 42 to prevent diffuse sources, - illustrated also through pictures and videos - has been realized, freely downloadable in different languages for the European advisers, technicians and farmers at the official TOPPS website (www.topps-life.org) as well as at the dedicated Italian website www.topps.unito.it.
Since 2012 dissemination of TOPPS BMPs among the Italian farmers advisers and consultants is carried out through specific training courses carried out in all Italian regions, where also the use of interactive tools supporting the farmers in the adoption of TOPPS BMPs (e.g. Drift Management Tool), is promoted and encouraged and still goes on in the ambit of TOPPS Water Protection project (2015-2018) mainly aimed at disseminating TOPPS BMPs and complete them regarding drainage and leaching.

Introduction

Plant protection products (PPP) are widely used to protect crops from damages due to insects, fungi and weeds. Incorrect use of pesticides and adverse weather conditions, however, may cause environmental contamination; especially surface water bodies may be severely polluted with negative consequences on water quality and on the ecological equilibrium of aquatic organisms. Environmental contamination due to Plant Protection Products (PPP) may originate either from point or from diffuse sources.
Point sources are typically related to the management of agrochemicals in the farm (Figure 1), where the preparation of the spray mixture, the filling of the sprayer tank, the cleaning of the spraying equipment at the end of the application and the disposal of remnants (spray mixture residues, washings containing PPP, empty PPP containers) are carried out. These operations are typically made always in the same area of the farm court, close to the water supply. Liquids containing pesticides are often poured on the soil and their infiltration

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may then contaminate surface and ground water bodies. According to several studies carried out in Northern Europe (Seel et al., 1996; Mason et al., 1999; Muller et al., 2002; Bach et al., 2005) more than 50% of water pollution phenomena with pesticides are due to point sources.

Figure 1: Example of point source generated when the spray mixture residue still present in the tank at the end of the application is discharged in the farmyard where the sprayer is usually filled and cleaned.

Diffuse sources (Figure 2) are mainly related to spray drift and to run-off that sometimes is also linked with erosion phenomena.

A B

Figure 2: Examples of PPP run-off (A) and spray drift (B).

Pesticide run-off in treated fields is generated by the action of water on the soil surface and just under the soil surface and is largely influenced by the soil and climatic conditions (soil type and structure, rain events), the topography (slopes and their orientation) and by the crop management (crop type, soil tillage type, time and mode of spray application, disposal of ditches).
Water contamination caused by spray drift, on the other hand, especially depends on the operative parameters adopted to apply pesticides (sprayer type, nozzles, forward speed, boom height in field crop sprayers, adjustment of air flow rate in air-assisted sprayers used on arboreal crops), on the environmental conditions occurring during spray application (wind velocity and direction, air temperature and humidity) and on the distance between the sprayed field and the sensitive areas (e.g. water courses).

The Best Management Practices to prevent point sources defined in TOPPS project (2005-2008)

Concerning prevention of point sources, in the period 2005-2008 a European Life Project named TOPPS (Training of Operators to prevent Pollution from Point Sources, www.topps-life.org) – funded by the European Union and by the European Crop Protection Association (ECPA) and involving research institutes from 15

different EU countries (DISAFA – University of Turin in Italy) – was carried out. Aim of the project was to point out the technical solutions applicable on sprayers and the farm infrastructures useful to contain risks of environmental contamination related to PPP point sources. A list of 117 Best Management Practices (BMPs), agreed at European level, was prepared and disseminated through training activities addressed to farmers and advisers. They were divided in six parts, according to the different phase of PPP management in the farm: 1) transport, 2) storage, 3) preparation of the spray mixture and introduction of PPP in the sprayer, 4) distribution of the spray mixture in the field, 5) cleaning of the sprayer at the end of the application, 6) remnants disposal. Each BMP is composed by a "statement" and some "specifications". The statement is a clear communication in form of very general recommendation of the universal use, which will constitute the European core of BMP (not subject to be modified in the national versions) and answers to the key question: "What to do?". The specifications are a detailed description of requirements, measures, materials, parameters to be used in order to meet the recommendation (may be subject to modifications in the national versions) and answer to the key question: "How to do?". An example of BMP about prevention of point source is reported in Table 1.

Table 1: Example of Best Management Practice about prevention of point sources.

BMP n°	Statement	Specifications
47	DO load and clean PPP containers with integrated sprayer equipment	• Use low level induction bowls with integral container rinse facility • Check with manufacturer that bowl loading/container rinse facilities are appropriate to your intended PPP use • PPP labels may detail specific requirements to load/clean – for example, larger pack sizes • Always load PPPs into induction bowls such that there is no risk of spill or splash or undue equipment contamination • Visually verify loading/cleaning performance in use • Check PPP label whether rinsing procedures are specified • Integrated pressure washers must be capable of cleaning the discharged PPP container such that <0.1% of its rated capacity is retained • Manual washing of discharged PPP containers must include a minimal triple rinse procedure with each rinsing added to prepared main tank solution

The Best Management Practices to prevent diffuse sources defined in TOPPS-PROWADIS project (2010-2014)

TOPPS-PROWADIS project was funded and coordinated by ECPA (European Crop Protection Association) and involved research institutes from seven EU countries (Spain, France, Italy, Germany, Belgium, Denmark and Poland). In each country two working groups were established, one dealing with spray drift and one dealing with agrochemicals run-off. In Italy both groups were based at DiSAFA University of Turin: the Crop Protection Technology unit leaded by Prof. Paolo Balsari worked on spray drift, while the Agronomy unit leaded by Prof. Aldo Ferrero worked on agrochemicals run-off.

In the first phase of the project documents concerning water contamination from agrochemicals diffuse sources, papers about the techniques and the strategies adopted to mitigate it and the available national/regional reference legislation documents on this subject were collected and analysed. In each country participating in the project a survey was then conducted through an ad hoc questionnaire submitted to stakeholders (institutions, advisers, farmer unions, farm consultants, etc.) in order to get a detailed overview about the present situation in terms of awareness concerning the subject of water pollution from pesticides and the mitigation measures adopted.

The survey involved 680 stakeholders in the 7 countries involved in the project, belonging both to public and private sectors: 38% of them worked in the ambit of farmers advice and education, 24% in regulatory, inspection, stewardship and water quality, 18% in PPP research and development, 13% in PPP – marketing.

Survey results showed that: 1) PPP are considered the main problem for surface water contamination followed by organic fertilizers; 2) herbicides are perceived as most critical among the PPP in terms of water contamination; 3) point sources are considered the main entry route of PPP to surface water; 4) runoff is perceived the main diffuse entry route, followed by spray drift; 5) riparian buffers and the correct application timing of PPP are considered the most effective mitigation measure to reduce PPP transfers from runoff / erosion; 6) anti-drift nozzles are the first preferred measure to reduce drift from field applications; 7) biggest potentials to reduce PPP entries into water is seen through the mitigation of spray drift from orchard/vine

applications; 8) creating awareness for water protection is seen to be reached most efficient by conducting trainings/demonstrations for PPP users and advisers.
Each of the two working groups established in the Project then started to prepare the Best Management Practices (BMPs). The path to define common BMPs agreed at European level has foreseen the preparation of a first proposal of BMPs made by the TOPPS-PROWADIS working group; this proposal was submitted in each country to national stakeholders in order to receive their comments and remarks; the latter were then discussed and considered for eventual amendments of BMPs within the TOPPS-PROWADIS working group and finally the definitive BMPs list agreed at European level was licensed. Structure of BMPs resulted different for spray drift with respect to run-off.
Also, in the ambit of TOPPS activities, a tool named EOS (Environmentally Optimised Sprayer, www.topps-eos.org) was developed to aid relevant stakeholders design or select spray equipment that helps to minimise the risk of losses of PPPs to water, focussing on field sprayers, and orchard / vine sprayers. Main objectives of EOS tool are: 1) to create awareness of the risk mitigation potential which exists in terms of equipment design and selection among manufacturers, advisers, farmers and authorities; 2) to create a platform for discussions among all players involved in the crop protection process to better understand each other's challenges and support further innovations; 3) to develop a commonly agreed basis for incentivising further improvements in spray equipment performance in terms of reducing losses of PPPs to water.
The EOS tool does not address operator training or behaviour (these important aspects are dealt with elsewhere in the TOPPS project BMPs), but focusses specifically on the mitigation potential of technical aspects or performance related to spray equipment design and devices which in turn enables operators to implement BMPs.

Best Management Practices to prevent spray drift

Following the scheme already adopted in the TOPPS Project in the period 2005-2008, the working group TOPPS-PROWADIS in charge to develop the BMPs about prevention of risks related to spray drift prepared 42 BMPs, each composed by a "statement" and some "specifications". An example of BMP about prevention of spray drift is reported in Table 2.

Table 2: Example of Best Management Practice about prevention of spray drift.

BMP n°	Statement	Specifications
16	Do not spray when wind speed exceeds the acceptable value	Check the label instruction and local regulations for preferable and acceptable weather conditions during PPP application. If no legal requirements about wind velocity are specified preferably spray at LOW and MEDIUM wind (0,5 - 3,0 m/s). In case of HIGH wind (3,1 - 4,0 m/s) if possible hold-up the PPP application until the wind slows down. If timing is a critical factor or for other reasons the PPP application cannot be postponed use the most efficient drift mitigation measures available. Never spray at VERY HIGH wind speed (>4,0 m/s).

A list of 42 BMPs plus 15 recommendations agreed between the European experts of the TOPPS-PROWADIS was produced and it was divided in three main sections:
1. General methods to reduce drift (valid for either field crop or fruit crop sprayers).
2. Methods to reduce drift generated from field crop sprayers.
3. Methods to reduce drift generated from fruit crop sprayers.
Two main approaches were considered: 1) prevention of spray drift generation at source (using Spray Drift Reducing Techniques – SDRT – like air induction nozzles, air sleeves on boom sprayers, shields, sensors, etc.); 2) mitigation of the negative effects of spray drift (e.g. through the adoption of buffer zones, natural or artificial windbreaks, etc.).

Best Management Practices to prevent spray run-off

Approach to define Best Management Practices to contain PPP run-off was made at wider scale with respect to BMPs about spray drift. This is due to the fact that run-off phenomena cannot be limited at farm scale but need to be considered within the whole river basin (Figure 3).

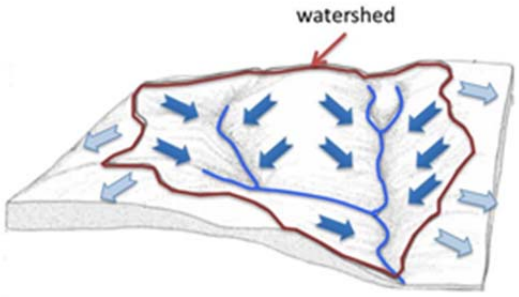

Figure 3: . Run-off is produced on a territorial scale. Water pollution may be caused either by up hill or by down hill fields and mitigation measures can be effective if adopted at farm level in the whole catchment area.

First aim of TOPPS-PROWADIS project was therefore to define common criteria to make the run-off vulnerability assessment in a defined catchment area, especially taking into account the soil characteristics and the orography. Combining the territorial data available (nature and structure of soils, slopes, rain events, etc.) with GIS maps it is possible to draw specific catchment maps for run-off risk assessment. These maps shall be then upgraded verifying in the field the presence of mitigation measures already adopted in the farms (e.g. riparian buffer strips, ditches, etc.) as well as the presence of erosion phenomena. After the diagnosis is carried out at field/catchment level, the diagnosis of individual fields should be done on the basis of the developed dashboards (Figure 4) to determine the runoff risk of the field. Based on the risk evaluation Best Management Practises can be adopted in a specific scenario (Figure 5).

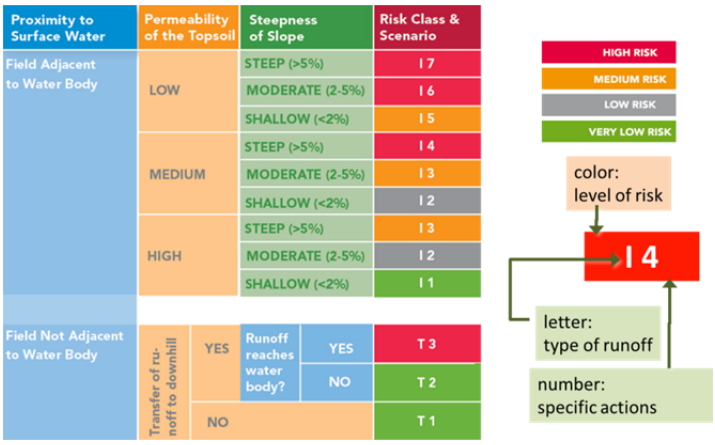

Figure 4: Example of dashboard related to infiltration restrictions.

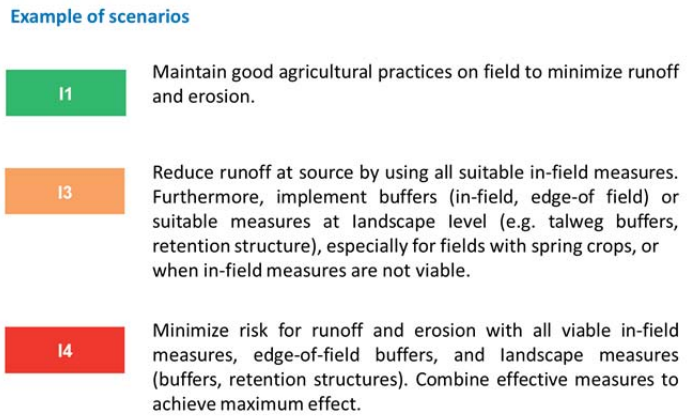

Figure 5: Example of Best Management Practices related to infiltration restrictions (see Figure 4) applicable in different scenarios.

The TOPPS Water Protection project (2015-2018) and the dissemination activity of TOPPS Best Management Practices in Italy

Starting from 2015 TOPPS activities are continuing in the ambit of TOPPS Water Protection project (2015-2018), that is mainly focussed on the intensive dissemination of all TOPPS BMPs, both for point and diffuse sources, involving also other European countries that were not involved in their development; moreover the completion of BMPs regarding the leaching and drainage aspects is considered.
Concerning the Italian context, since 2012 dissemination of TOPPS BMPs among the Italian farmers, advisers and consultants has been carried out through specific training courses, realised by DiSAFA – University of Turin with the support of Agrofarma (National Association of Agrochemicals Companies). These training courses were held in all Italian regions, promoting also the use of interactive tools supporting the farmers in the adoption of TOPPS BMPs (e.g. Drift Management Tool, freely downloadable at the website www.topps-drift.org) and making practical demonstrations about the implementation of the Best Management Practices in the farms have been illustrated. In the period 2012-2016 a total of 15 TOPPS two-days training courses (one day dedicated to BMP about prevention of point sources and spray drift and one day dedicated to BMP about prevention of spray run-off) were held in 13 different Italian Regions, involving more than 750 participants, mainly farm advisers. Booklets, leaflets and videos to disseminate TOPPS BMPs about prevention of point sources, spray drift and run-off were produced and delivered to the participants to the training courses, as well as uploaded and made freely downloadable either on the TOPPS Project official website (www.topps-life.org) or on the dedicated Italian TOPPS website (www.topps.unito.it).
Moreover, in 2015 and in 2016 two editions of a three-day TOPPS Academy course, addressed to European key stakeholders, were held at DiSAFA University of Torino to illustrate the TOPPS BMPs and the available instruments to promote their implementation at farm level.
Also in 2017 further four two-days training courses about the implementation of TOPPS BMPs are scheduled respectively in Veneto, Marche, Campania and Sardinia Italian regions.

Conclusions

BMPs about prevention and mitigation of point sources, spray drift and run-off, that were developed in the ambit of TOPPS and TOPPS-Prowadis projects between 2005 and 2011 are now being disseminated in Italy through specific training and demonstration activities countries. These dissemination activities are mainly addressed to farmers and advisers and are carried out by DiSAFA – University of Turin with the support of Agrofarma.
This dissemination activity is in line with the recommendations of the EU Directive on sustainable use of pesticides (128/2009 EC), as it will provide concrete measures and tools for preventing surface water pollution due to pesticide application.

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