

144. Precision application of plant protection products in agriculture: role of the European Precision Application Task Force (EUPAF)

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Abstract

Agricultural practices in Europe are undergoing a significant evolution towards precision technologies, reflecting rapid technological developments in digital sciences and agricultural equipment, as well as political will towards sustainable agriculture. Precision applications are part of this evolution, and, within the regulatory context, different stakeholders have undertaken to study the consequences of the evolution of application technologies for crop protection on risks and risk assessment. The EUPAF (European Precision Application Task Force) was established in June 2023 to provide a scientific platform for experts in equipment, farmers, scientists performing risk assessments from public and private organizations, and researchers to exchange information about these technologies and discuss the way forward for their inclusion in regulatory process. This manuscript will give an overview of the structure, activities and objectives of the EUPAF.

Keywords: pesticide, precision application, risk assessment, risk management, risk reduction

Introduction

Technological developments in agriculture equipment, including digital science have seen a fast acceleration over the past few years (Matthews *et al.*, 2014), driven by sustainability policies (EC, 2020), but also economical reasons leading farmers to move towards precision and water and plant protection products saving options. The rapid diversification of precision applications (PA) of crop protection products resulting from this evolution triggered a consensus among stakeholders to investigate the implications from a regulatory point of view and more particularly, on how to define a precision use in terms of risk assessment and product labelling, to better reflect the implementation of those application techniques as part of risk reduction objectives (EC, 2009). In the context of this paper, precision applications correspond to any application kind that aims at the pest to be controlled and avoids direct application on the areas around the pest (when this is not intended), such as spot or patch applications, for example.

The European Precision Application task force (EUPAF) created counts 117 experts, which come from regulatory authorities (43), crop protection companies (37), equipment manufacturers/farmers (14), as well as contract organizations (11) and academia (12). The expertise is organized around six tasks identified by the experts during a preparatory workshop (EUPAF, 2023):

1. Identification of use categories (or use cases) describing the precision uses of plant protection products (PPP), based on an inventory of equipment and corresponding treatment purposes.

2. Development of an approach to accurately describe these use categories, to be used in the uses table of plant protection products (or Good Agricultural Practices - GAP table, EC, 2009, EC, 2024).
3. Identification of implications for risk assessment scenarios and potential as risk mitigation measures (RMM) for each use case.
4. Inventory of possible options for risk assessments tailored to each use case.
5. Preparation of data describing a precision application category to feed into the Compendium on risk mitigation measures and precision applications of the European Commission (EC, 2024).
6. Development of equivalence tables for the performance of tools in terms of risk reduction and use reduction, allowing recognition and harmonization among European countries.

The recommendation from the task groups (TG) should be seen as flexible and are open for adaptation as new information from another TG becomes available. This is important to keep the requirements as simple as possible. The development of equivalence tables is therefore highly important and will be part of the upcoming work of TG 6.

This article presents a summary of the ongoing efforts of the EUPAF working group in the field of precision applications in field crops and low crops in general (2D crops), and more specifically will illustrate how the 6 steps described in the above tasks enabled to propose possible approaches to integrate precision uses in the regulatory context of PPP registrations.

The paper will present the resulting use categories and how they could be captured in a GAP table, and discuss how they can impact the risk assessment performed in the regulatory context of PPP registration. The results are preliminary and might undergo further refinement to ultimately be tailored to the requirements of all the stakeholders which are involved.

The task force is also developing this approach for perennial crops, vineyards, and orchards, which will be presented later.

Material and methods

The inventory of precision uses in field crops and low crops (2D crops) (task 1) is based on the practical knowledge of experts from the working group TG1 in the field of technologies used in various crop groups. These uses and the equipment involved are described in a working document, which will soon be published. Each use is described using the following attributes: treatment purpose and objective, reliance on any preliminary observations and data recording prior to treatment (e.g., location of targets to be treated such as weeds), a precise description of the treated area (e.g., spot or patch), application resolution, performance, or effectiveness in controlling targets, ease of implementation, and cost. The resulting inventory has been used to define classes of use reduction, representing the range in the volumes of plant protection products permitted by the equipment and practice, compared to a broadcast application.

Based on the inventory, experts have developed a harmonized/standard description of the use categories to be used in regulatory dossiers for plant protection products, which will soon be published (expected date of publication by the end of 2025). Regulatory dossiers require a detailed description of each use of a product (crop, targeted pest, application type and application rate) into a standardized document called Good Agricultural Practice table (or GAP table; Article 31 of EC, 2009 and EC, 2024). TG 2 has developed a description of the new precision use categories for this regulatory format (task 2) and discussed the EPPO (2021a and b) and ISO (2020) codes and definitions to be included, the mode of observation or recording of the zones to be treated, the dose of product applied ha⁻¹ when performing a broadcast application and the percentage of reduction of this dose as a result of using the considered precision application technology.

The implications in terms of exposure and risks are specific to each use. The TG3-4 working group analyzes application conditions for each precision application category and identifies sections

of the risk assessment for which a significant difference is anticipated compared to worst-case conditions (full application), justifying a dedicated risk assessment. This corresponds to the tasks 3 and 4 identified above. For example, a spot application targeting thistles only and using 15% of the quantity of product that would be applied on the whole field, results in a significant reduction of product reaching the soil and susceptible to leach to groundwater. If a dedicated risk assessment is justified, the TG3-4 group develops calculation options based on available data or models and proposes new approaches where applicable.

Once a use category has been described and analyzed by the TG2 and TG3-4 working groups, a group, the TG5 working group, is responsible for gathering the collected data resources to enable regulatory organizations to take over and decide on integration into regulatory dossiers (task 5).

The gathering of equivalence tables illustrating the performance of precision use methods and equipment (task 6) will be initiated at a later stage on the basis of the output of tasks 1, 2 and 3 & 4.

Results

The inventory of precision applications by sprayer in field crops is being listed by the TG1 working group and will be published by summer 2025 in the form of a report on the EUPAF platform webpage (https://www.bvl.bund.de/DE/Arbeitsbereiche/04_Pflanzenschutzmittel/01_Aufgaben/02_ZulassungPSM/05_psm_EUPAF/psm_EUPAF_node.html).

This inventory includes a review of application techniques used by farmers, employing traditional sprayers as well as sprayers equipped with new technologies. It includes field feedback and questionnaires reflecting the implementation and adoption of new techniques as collected in some countries (e.g., by Witzke and Herchenbach, 2022). The percentage reduction in the use of plant protection products by precision method is also reported, along with the main contributing factors. Figure 1 illustrates the types of precision applications described in the inventory, for which a pictogram has been defined by the TG2 working group. As reference, pictograms for broadcast

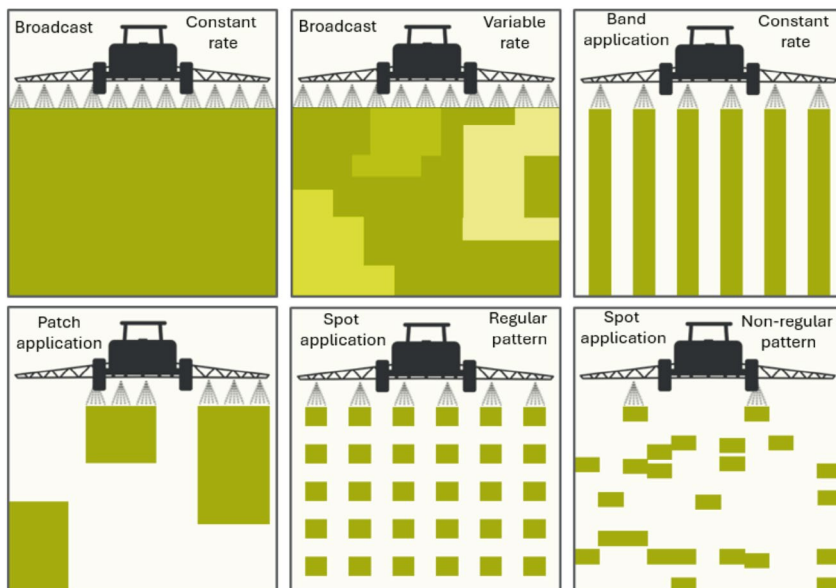


Figure 1. Types of precision application in field crops and corresponding pictograms, as developed by EUPAF.

application (constant and variable rate) are included. The types of precision application have been grouped into categories: band, patch and spot application (regular and non-regular pattern). Variable rate applications are possible for each of these categories. A use description is then proposed by working group TG2. An illustration for specific thistle control in sugar beet is shown in Figure 2. The table in Figure 2 describes a targeted application of a product by spray on thistles, after recognition of the thistles using sensors mounted on the sprayer and resulting in a spot application, irregular (performed on the thistles and therefore not following a regular pattern) and by the equipment that “detect” and “apply” (online).

In compliance with regulatory requirements, information on the target, the type of application, growth stage of the crop at the time application and volumes of product and water used are included in the GAP table. The description also includes an indication of the maximum cultivated area receiving the treatment. The table provides the maximum application rate per plot and per treated area for a single application (a) and where multiples applications are recommended (b). It is important to note that where spots only are treated, the “application rate” remains unchanged, since the concentration of product in the application solution (in the tank) remains unchanged, but the overall dose used on the plot is reduced. The reduction in product volume is calculated by comparing the volume applied in for the spot application with the volume applied for a broadcast application. This corresponds to the numbers between brackets in the table. This information can serve as a basis to discuss implications in terms of risk reduction for the different areas of the risk assessment.

In this example, the application is carried out only on targeted spots for thistles, using a sprayer equipped with a thistle detector. After detecting the thistle, the spray is directed selectively on the thistle. The reduction in herbicide use is 50%, calculated by comparing the volume applied on the thistle spots (0.625 l of product) with the volume that would be applied in a broadcast application (1.25 l of product). In the case of an application performed with a sprayer not equipped with detectors, the description of the precision use is the same, but the type of use indicates that the application is performed “offline,” meaning after the observation operations for counting thistles, which can be carried out before spraying, either automatically (e. g. by drone) or visually. Figure 3 illustrates the result of counting and recording thistles on one of the plots, indicating the detection-positive areas and the areas receiving the product.

The TG2 working group is also preparing a guide for describing precision uses and filling out GAP tables that will be published on the EUPAF webpage, along with proposals for describing precision

Category	Product formulation type, concentr. Active substance in the product	Crop and / or situation (crop destination / purpose of crop)	Pest or Group of pests controlled	Method / Kind (dispenser, rate variation, application category, max. area treated)	Timing / Growth stage of crop & season	Max number a) per use b) per crop / season	Min interval between applications (days)	Product (L/ha, kg/ha) a) max rate per treated area (max. field average application rate) b) max total rate per treated area and crop / season / year (max field average rate per crop / season / year)	kg a.s. / ha a) max rate per treated area (max. field average application rate) b) max total rate per treated area and crop / season / year (max field average rate per crop / season / year)
Broadcast application	Herbicide A	Sugarbeet	Broadleaved weeds	Broadcast foliar, downward spray, constant rate	BBCH 31-39	a) 1 b) 1	NA	a) 1.25	a) 0.125
	SL 100 g/l							b) 1.25	b) 0.125
Spot application	Herbicide A	Sugarbeet	Broadleaved weeds	Spot (3SPOTM), non regular, downward spray, constant rate, sensing, maximum 50 % of area sprayed	BBCH 31-39	a) 1 b) 1	NA	a) 1.25 (0.625)	a) 0.125 (0.0625)
	SL 100 g/l							b) 1.25 (0.625)	b) 0.125 (0.0625)

Figure 2. Description of a treatment of thistles in beet cultivation by spot application, in a GAP table, compared to a broadcast application.

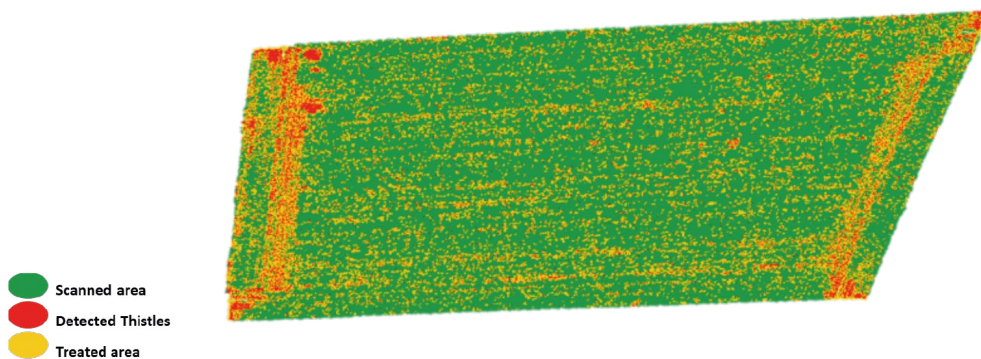


Figure 3. Map of a sugar beet plot showing the scanned area (in green), the area where thistles were detected (in red), and the treated area (in yellow). A yellow spot (area covered by two nozzles) is 50×192 cm.

uses in illustrative GAP tables for each category. This guide will be accompanied by a glossary based on EPP0 and ISO definitions, providing additional definitions where applicable.

The TG3-4 working group then defines how precision application is likely to alter the exposure of various environmental compartments as well as human exposure to the product compared to full application. To do this, the working group relies on the information provided in the GAP table and, if necessary, requests that further details be added to the description of the use. Table 1 lists the compartments of the environment subject to risk assessment for a full herbicide application and the expected modifications in the case of a precision application on thistles, as described in Figure 2.

Discussion

While a reduction in quantity of product being applied to a plot following a precision use is a significant step in reducing pesticide pressure, other factors will define the actual implications in terms of risk reduction, through an analysis of exposure pathways and major exposure compartments:

- Location of the application: This defines whether significant exposure via the crop is expected, and thus whether the risk assessment for consumers and non-target organisms feeding on the crop is affected. For example, targeted herbicide application on weeds results in reduced exposure compared to full application that includes the crop. In the above example (targeted treatment of thistles), the targeted application leads to a significant reduction in residue levels on the crop itself. As a result, the exposure of non-target organisms coming into contact with plants in the field and the exposure of consumers after harvest and processing of beet plants must be reassessed.

- Resolution of the detection and application and associated uncertainty: Related to the equipment used for the application, this is crucial in measuring the effective volume used to treat targets and the possibility of deposits next to the target. A precision application on thistles detected on 15% of a plot, for example, will lead to the treatment of different areas depending on whether the sprayer opens one or two nozzles, and according to the resolution of the nozzle.
- The stage of application: on the crop, it is decisive in the exposure of the consumer and non-target organisms feeding on the crop, as well as in the quantity of product intercepted by the crop.

Current exposure calculation tools allow for defining expected exposure levels after full applications, which represent the “realistic worst-case” that will cover the vast majority of situations encountered in the field. Thus, the maximum allowed application rate is always considered, and plots are parameterized to represent situations vulnerable to transfers to groundwater or surface water. Taking the treated area into account in the risk assessment allows to better reflect product flows

Table 1. Compartments and risk categories for human health and the environment for broadcast herbicide application and in the case of spot control of thistles in sugar beet.

Compartment/risk category	Broadcast application	Spot application on thistles
Groundwater	Risk assessment based on application over the entire plot, transfer to a groundwater table	Reduced transfer proportionally to the amount of product applied, conversion factor=% reduction in product volume applied
Surface water: drainage	Risk assessment based on application over the entire plot, transfer via drainage	Reduced transfer proportionally to the amount of product applied, conversion factor=% reduction in product volume applied
Surface water: runoff	Risk assessment based on application over the entire plot, transfer via runoff	Reduced transfer proportionally to the amount of product applied, with the effect of the treatment location in the plot, specific modelling required
Surface water: spray drift	Risk assessment based on application over the entire plot, transfer via drift	Transfer dependent on the amount of product applied at the edge of the plot, specific modelling required
Soil organisms	Risk assessment based on application over the entire plot	Reduced exposure for some soil organisms, affected by the mobility of these organisms, specific exposure calculation required
Small vertebrates	Risk assessment based on application over the entire plot and exposure via consumption of plants and animals	Reduced exposure via plants (thistles and potential drift), reduced exposure via animals, specific exposure calculation required
Invertebrates (non-target arthropods and pollinators)	Risk assessment based on application over the entire plot and exposure via plants and soil	Reduced exposure via plants (thistles and potential drift), exposure via soil, specific exposure calculation required
Consumers	Risk assessment based on application over the entire crop	Reduced exposure (no direct application on beets), consideration of drift on the crop and uptake via soil, depending on the application stage

representing a risk of transfer to the different compartments of the crop, but may require the development of exposure scenarios tailored to different transfer modes and non-target organisms. Simple conversion factors that can be directly applied to exposure calculations for “homogeneous” and “static” compartments corresponding to the “worst-case” in models (e.g., a groundwater table directly connected to the treated plot) must be supplemented with scenarios that take into account the non-homogeneous nature of other compartments (e.g., the soil of a plot treated by patch) and the mobility of organisms in this compartment (e.g., earthworms in this plot). The TG3-4 working

group is working on defining options that can be used in short- and medium-term risk assessment scenarios based on current data and models, and to integrate new data into more complex models. Therefore, EUPAF is also involved in the project AGROS-II to generate data from field data to compare spray drift and deposition from spot spraying with broadcast application (<https://www.wur.nl/en/research-results/research-institutes/plant-research/business-units/greenhouse-horticulture/show-greenhouse/agros-ii-project-launched.htm>).

Finally, the EUPAF task force is considering the possibility of integrating factors in the exposure of compartments into the risk assessment, to prepare for the future and the acquisition of application data simultaneously with the application itself. In this type of application, the detection of targets to be treated is coupled with the application and measurement of other parameters (location, resolution, growth stage, as well as weather conditions, geolocation, and potentially location relative to protected areas, vulnerable transfer conditions to groundwater, etc.). The risk could then be reassessed “in situ” and allow for adaptation of application conditions to a given situation. This type of exposure assessment involves taking into account successive levels of complexity and requires designing scenarios and risk assessment models today so that they can integrate this complexity in the future.

Conclusion

The development and deployment of precision application technologies and practices respond to the expectations of reducing the environmental footprint of phytosanitary practices essential to defining sustainable agricultural practices. These developments also represent a challenge for regulatory assessment, as they call for an evolution of assessment models alongside technological advancements to quantify the benefits and improvements resulting from these technologies and to support decision-making considering these developments. The EUPAF hopes to provide foundational scientific elements for the development of adapted calculation models by analyzing existing techniques and practices and integrating future developments. The progress of the working group is accessible online on the EUPAF webpage as mentioned above.

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References

- EC (2009) Reg.(EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market. OJ EU 24 November 2009. EU, Brussels.
- EC (2020). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, EU biodiversity strategy for 2030: Bringing nature back into our lives. EU Commission, Brussels.
- EC (2024). Compendium of conditions of use to reduce exposure and risk from plant protection products, PAFF-PPL-March 2024-Doc.A.07.02 23 May 2024. Available online at https://food.ec.europa.eu/document/download/cdd9b6c4-29dc-4077-a118-3e51c0abeb80_en?filename=pesticides_ppp_app-proc_guide_horiz_comp-cond.pdf (accessed February 2025).
- EPPO (2021a) PP 1/248 (3) Harmonized system for classification and coding of the uses of plant protection products, EPPO Bulletin. Available online at https://www.eppo.int/media/uploaded_images/ACTIVITIES/plant_protect_products/pp1-248-3-e.pdf (accessed February 2025).

- EPPO (2021b) PP 1/239 (3) Dose expression for plant protection products, EPPO Bulletin, 51(1), 10–33. <https://doi.org/10.1111/epp.12704>
- EUPAF. (2023) Report of the online workshop digital agriculture and precision farming, 21 and 22 February 2023 Available online at https://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/01_EUPAF_Information/Fresenius_Conference_2023_Programme_Digital_Agriculture_Precision_Farming.pdf?__blob=publicationFile&v=2 (accessed February 2025).
- ISO. (2020). Equipment for crop protection – vocabulary. Available online at <https://www.iso.org/standard/72299.html> (accessed February 2025).
- Matthews, G.A., Bateman, R., & Miller, P. (2014). Pesticide application methods, fourth edn. Wiley, Chichester. DOI:10.1002/9781118351284
- von Witzke, K., & Herchenbach, M. (2022). Technik im Pflanzenschutz bei Landwirten in Deutschland Ergebnisbericht einer Befragung. Available online at https://www.iva.de/sites/default/files/2022-07/Technik%20im%20Pflanzenschutz_Ergebnisbericht_220722.pdf (accessed February 2025).