

EUPAF — General considerations on environmental risk assessment of 3-D (canopy) precision application of plant protection products in orchards and vineyards.



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INTRODUCTION

Precision application (PA) is transforming the environmental risk assessment (ERA) of plant protection products (PPPs) in complex bush/tree/3-D systems such as orchards and vineyards. PA better targets PPPs within the 3-D crop canopy—via GPS-guided sprayers, LiDAR mapping, remote sensing and application technique/technology options such as face-to-face (F2F) sprayers. Better spray targeting, and timing, result in improved spray efficiency and reduced off-target losses (e.g. Xun *et al.*, 2023). Established ERA frameworks must evolve to capture this heterogeneity. A tiered framework that integrates 3-D precision application into regulatory ERA is outlined.

Key drivers & the scientific challenge

- The core challenge is measuring 3-D PPP distribution and its efficacy and effects on non-target organisms and environmental compartments.
- Current ERA schemes simplify 3-D application into 2-D deposition, reducing accuracy.
- Advanced tools—CFD, spatially explicit risk mapping, and probabilistic exposure models—are needed to simulate 3-D PPP distribution.

MATERIALS & METHODS

Regulatory frameworks (e.g. FOCUS, EFSA) assume uniform pesticide application and 1-D exposure via drift deposition and runoff factors. In 3-D crops like orchards, spray deposition is spatially uneven, depending on canopy structure, growth stage, weather and application technology. To improve realism, a tiered framework is proposed, ranging from standard regulatory scenarios to site-specific 3-D modelling. A Deposition–Pathway Profiling Database and the Target Application Equivalence concept are pursued, with a conventional axial-fan sprayer as a reference.

Main components

- Tier 1–3: from standard assessment to spatially explicit 3-D modelling.
- Options tested: profiling database and target application equivalence.
- Reference: traditional axial-fan sprayer (unadjusted) – EPPO Code 3AIRBM.
- Deposition pathways: foliar interception, in-field ground loss, and off-field drift (airborne and sedimented).

RESULTS & DISCUSSION

What the evidence shows

3-D precision application directs more of the applied dose to the canopy and reduces off-target losses, e.g. marked reductions in ground and airborne drift and pesticide savings of up to 43% (Xun *et al.*, 2023). Localised Precision Applications may target only specific parts of the crop canopy, e.g. the grape bunch zone [see EPPO PP 1/239(3) (2020) as a key document (covering both dose transformation and localised applications)], or indeed specifically target only infected areas, the fruit, etc. The key consequence for risk assessment is a shift in how the applied mass is partitioned across deposition pathways: on-target deposition (efficacy and consumer risk), direct in-field ground loss and off-field ground drift (soil and non-target terrestrial exposure) and airborne drift (operator, bystander, pollinator, and longer-range transport) (Figure 1). For environmental exposure, immediate attention focuses on direct ground loss and ground drift, the pathways most relevant to soil, groundwater, and off-field non-target organisms. A tiered assessment framework of environmental exposure for applications to 3-D crops is proposed (Figure 2).

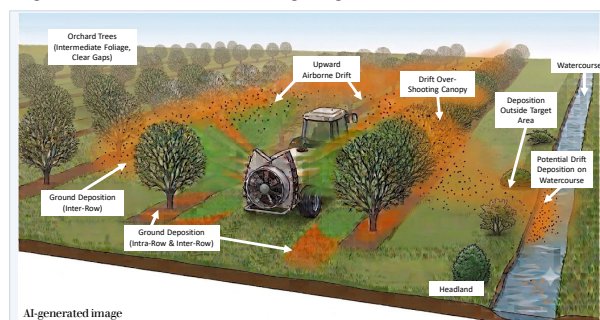


Figure 1. Schematic for axial fan airblast sprayer in a globular tree crop with intermediate foliage

What it means for risk assessment

- Current frameworks so far generally assume uniform, field-wide application limiting the scope to credit precision application techniques.
- Representing 3-D applications requires a true mass balance across row, inter-row, and off-field losses (f_{row} ; $f_{inter-row}$; $f_{off-field}$) plus canopy interception — and, critically, airborne drift, which the current mass-balance approach omits and therefore does not yet close the balance.⁽¹⁾
- Regulatory defaults are retained and refined only where needed — e.g. drift evidence or in-field partitioning via canopy and inter-row collectors.
- Two pragmatic strategies are emerging: a deposition-pathway profiling database (piloted with Performance Pulvé, WUR, JKI), and a "target-application-equivalence" concept allowing a technique with equal-or-lower local deposited dose than a reference sprayer to rely on the existing risk assessment.
- Crop type matters. Approaches must distinguish "wall" production (vines, pome fruit) from "globular" crops (citrus, olives).

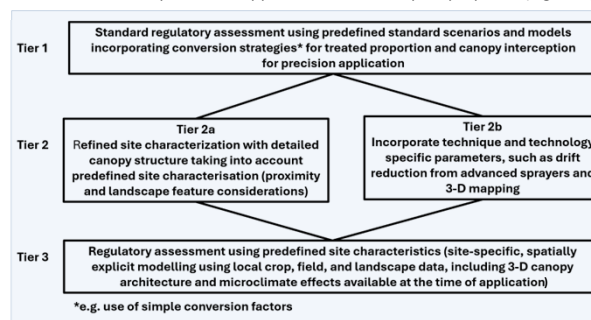


Figure 2. Proposed tiered assessment framework of environmental exposure assessment for applications to 3-D crops

CONCLUSIONS

- 3-D precision application may improve application efficiency and reduce environmental loading.
- Current ERA frameworks developed for 2-D systems may not be fully applicable to spatially heterogeneous 3-D crop systems and precision agriculture. To address this, ERA should better reflect the actual deposition and exposure patterns that occur within such three-dimensional canopies. Where mass balance is referenced, its current limitations should also be acknowledged.
- Future work should distinguish between wall and globular production systems, clarify dose reference concepts such as g a.s. ha⁻¹ versus Leaf Wall Area and generate field and modelling data to refine exposure models, address remaining uncertainties for human-health and ecological risks, and support updated regulatory guidance.

REFERENCES

- Xun, L. *et al.* (2023) Advanced spraying systems to improve pesticide saving and reduce spray drift for apple orchards. *Precision Agriculture* 24(4): 1526–1546.
- EPPO PP 1/239(3) (2020) Dose expression for plant protection products <https://pp1.eppo.int/standards/PP1-239-3>
- EUPAF publication on Flexible Risk Mitigation in field/arable/2D crops https://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/01_EUPAF_Information/Subgroup_Flexible_Risk_Mitigation_EUPAF_Approach.html

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FOOTNOTE

⁽¹⁾ Note, however, that ISO 22866 does not mandate airborne drift measurement, and its optional measurements are inadequate for assessing losses in bush/tree/3-D crop spraying