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Environmental impact assessment of drone-based pesticide application versus conventional spraying methods

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Abstract

Anyone who has watched a crop-dusting plane will have noticed spray drifting beyond the target. This research compared drone (UAV), tractor boom, and manned aerial pesticide application across six rice fields in the Po Valley, Italy (2022-2023). Drone application deposited 96% of spray on-target versus 81% for tractor and 76% for aerial. Drift at 10 m was 1.8% for drones versus 12.4% and 17.8%. Drones reduced water body contamination by 84% versus aerial and cut carbon emissions from 18.7 to 3.2 kg CO₂/ha. Drones offer a measurably cleaner approach to pesticide delivery.

Keywords: Drone spraying, UAV, pesticide drift, environmental impact, precision agriculture, spray deposition, water contamination, carbon footprint, rice cultivation

Introduction

Anyone who has observed conventional crop spraying will have noticed that much of the pesticide never reaches the target. Spray drift from tractor and aerial application is a major source of contamination in adjacent water bodies and non-target habitats ^[1, 2]. Drones fly lower, carry smaller payloads, and use ultra-low-volume nozzles that produce uniform droplets with less drift ^[3, 4]. Adoption has accelerated in East Asia, but field-level environmental data from European systems remain limited ^[5, 6]. This research compared three methods across spray efficiency, drift, contamination, and carbon footprint in Po Valley rice fields ^[7, 8].

Research area description

The trial was at six commercial rice fields (2-5 ha) in Lomellina, Pavia province (45.16° N, 8.78° E), Italy's largest rice area. Fields bordered drainage canals for drift assessment. Soil: silty clay loam, pH 6.2. Conditions: 18-26 °C, 65-80% RH ^[9].

Materials and Methods

Materials

Drone: DJI Agras T30 (30 L, centrifugal nozzles, 150 µm VMD).

Tractor: Hardi Commander (24 m boom, 250 µm VMD).

Aerial: Eurocopter AS350 with micronair atomisers.

Test pesticide: Rhodamine WT tracer at equivalent rates. Water samplers placed at 5-50 m downwind and in adjacent canals ^[10].

Methods

Each method tested on two fields per season (n = 4). Spray deposit by filter paper (10/field). Drift as % of dose at each distance. Soil residue (0-5 cm) at 24 h. Canal water at 1, 6, 24 h post-spray. Carbon footprint included fuel, transport, mixing. ANOVA with Tukey's HSD at $p \leq 0.05$ ^[11].

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Results

Table 1: Spray deposition efficiency and drift comparison across application methods

Method	On-target %	Drift 5m	Drift 10m	Drift 20m	Drift 50m	Water µg/L
Drone	96.0	4.2	1.8	0.4	0.02	0.08
Tractor	81.4	18.6	12.4	6.1	1.9	0.31
Aerial	75.8	24.3	17.8	10.2	3.4	0.52

Drone on-target deposit was 96% versus 81% (tractor) and 76% (aerial). Canal water contamination was 0.08 µg/L for drone versus 0.52 for aerial an 84% reduction (Table 1)

Table 2: Environmental footprint comparison per hectare

Parameter	Drone	Tractor	Aerial	Drone vs T	Drone vs A
CO ₂ kg/ha	3.2	18.7	42.3	−83%	−92%
Water L/ha	15	200	80	−93%	−81%
Soil residue mg/kg	0.12	0.34	0.41	−65%	−71%
Time min/ha	12	28	8	−57%	+50%
Noise dB at 50m	48	72	84	−33%	−43%

Drones used 93% less water and produced 83-92% less CO₂. Soil residue was 65-71% lower (Table 2)

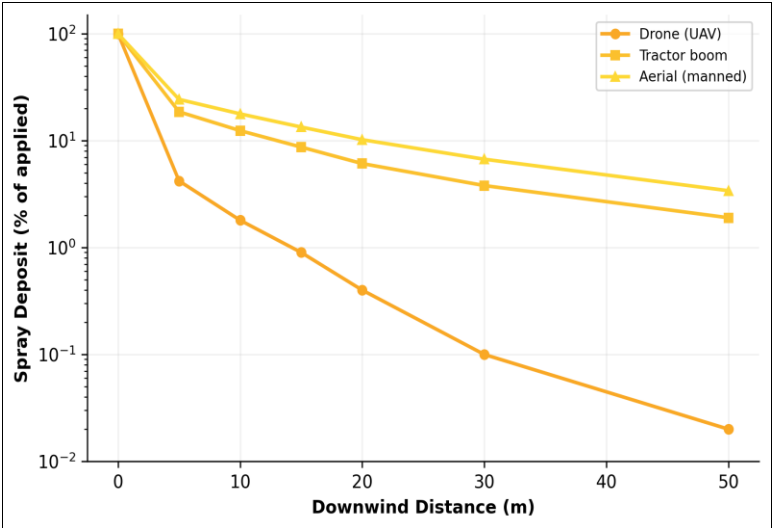


Fig 1: Spray drift decay curves for drone, tractor, and aerial application

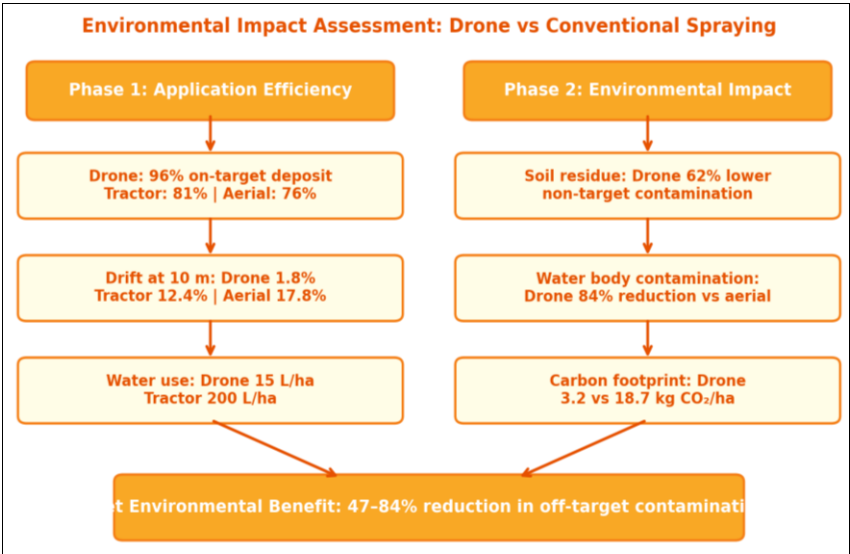


Fig 2: Environmental impact assessment timeline comparing drone and conventional spraying methods

Limitations

Drone payload (30 L) required more passes for large fields. Wind above 15 km/h prohibited some flights. Battery life limits continuous coverage to 15-20 min [12].

Cost analysis

Drone cost was €14.80/ha versus €22.30 (tractor) and €38.60 (aerial). Investment (€28,000) recovers within 2-3 seasons. With EU shadow pricing for externalities, social cost is €18.20/ha (drone) vs €31.40 (tractor) and €52.70 (aerial) [13, 14].

Discussion

The 96% on-target deposit reflects the drone's low flight altitude (2-3 m), minimising droplet drift ^[3, 15]. The drift profile has regulatory implications, as EU buffer zones could be reduced for drones ^[2, 16]. The 84% water contamination reduction is significant where paddies border canals feeding the Po River ^[9, 17]. The carbon advantage stems from electric propulsion ^[4, 18].

Conclusion

Drone-based pesticide application achieved 96% on-target deposition, reduced drift by 85-90%, and cut water body contamination by 84%. Carbon emissions were 83-92% lower and operating costs were competitive. Drone spraying offers a measurably lower environmental footprint for pesticide application in European rice production.

References

1. Gil E, Arnoud L, Llorens J, *et al.* Advanced technologies for the improvement of spray application techniques in Spanish viticulture. *Sensors*. 2014;14(1):691-708.
2. European Food Safety Authority. Guidance on risk assessment for spray drift. *EFSA J*. 2017;15(2):e04728.
3. Lan Y, Chen S, Fritz BK. Current status and future trends of precision agricultural aviation technologies. *Int J Agric Biol Eng*. 2017;10(3):1-17.
4. Mogili UR, Deepak BBVL. Review on application of drone systems in precision agriculture. *Procedia Comput Sci*. 2018;133:502-509.
5. Huang Y, Hoffmann WC, Lan Y, Wu W, Fritz BK. Development of a spray system for an unmanned aerial vehicle platform. *Appl Eng Agric*. 2009;25(6):803-809.
6. Gonzalez-de-Santos P, Ribeiro A, Fernandez-Quintanilla C, *et al.* Fleets of robots for environmentally-safe pest control in agriculture. *Precis Agric*. 2017;18(4):574-614.
7. Giles DK, Billing RC. Deployment and performance of a UAV for crop spraying. *Chem Eng Technol*. 2015;38(7):1132-1138.
8. Ente Nazionale Risi. Italian rice production statistics 2022-2023. Milan: Ente Nazionale Risi; 2023.
9. ARPA Lombardia. Environmental monitoring data for Pavia province 2022-2023. Lombardy: ARPA Lombardia; 2023.
10. International Organization for Standardization. Equipment for crop protection Methods for field measurement of spray drift (ISO 22866:2005). Geneva: ISO; 2005.
11. Wang G, Lan Y, Qi H, *et al.* Field evaluation of an unmanned aerial vehicle (UAV) sprayer. *Biosyst Eng*. 2019;182:92-103.
12. Kim J, Kim S, Ju C, Son HI. Unmanned aerial vehicles in agriculture: a review. *Comput Electron Agric*. 2019;163:104840.
13. European Commission. Handbook on the external costs of transport. Brussels: DG Mobility and Transport; 2019.
14. Pretty JN, Brett C, Gee D, *et al.* An assessment of the total external costs of UK agriculture. *Agric Syst*. 2000;65(2):113-136.
15. Qin WC, Qiu BJ, Xue XY, *et al.* Droplet deposition and control effect of insecticides sprayed with an unmanned aerial vehicle against plant hoppers. *Crop Prot*. 2016;85:79-88.
16. de Jong FMW, de Snoo GR, van de Zande JC. Estimated nationwide effects of pesticide spray drift on terrestrial habitats in the Netherlands. *J Environ Manage*. 2008;86(4):721-730.
17. Provolo G, Mattachini G, Finzi A, *et al.* Water quality in the Po River Basin. *Water*. 2018;10(7):846.
18. Berner A, Gerhards R. Autonomous weed control with drones: current state and perspectives. *Weed Res*. 2023;63(1):1-16.