Uncrewed Aerial Spray Systems and Equivalency with Conventional Techniques: Spray Drift, Operator Exposure, Crop Residue, and Efficacy

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Pesticide applications made by UASS are an emerging practice being incorporated into a multitude of use profiles

- Compared to Knapsacks
  - Increase productivity / reduced operator exposure / improved operator safety on difficult terrain
- Compared to Ground Equipment
  - Access hard to reach locations / separate operator from the sprayed area / decreased crop damage and soil compaction
- Compared to Crewed Aircraft
  - Less expensive technology / non specialized / treat smaller targets than crewed aircraft
- UASS need to be fully incorporated into our regulatory frameworks, but we are lacking appropriate data

Drone used for vector control in a hard-to-access location. (Courtesy of Clarke)

One of the Recommendations in the OECD State of the Knowledge – Literature Review on Unmanned Aerial Spray Systems in Agriculture

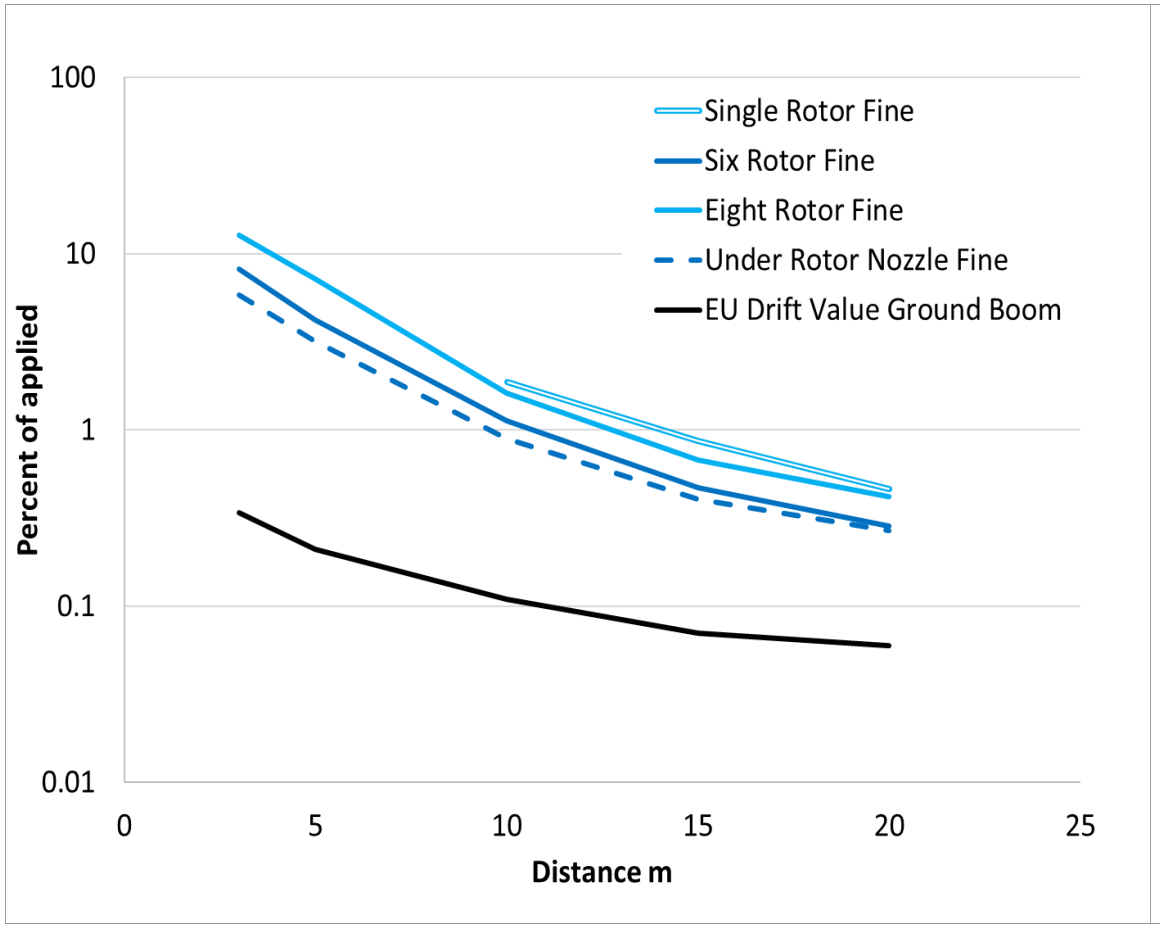
- There is potentially enough information to compare the drift profiles of drones to other conventional application types. https://www.oecd.org/chemicalsafety/pesticides-biocides/literature-review-on-unmanned-aerial-spray-systems-in-agriculture.pdf
- One of the largest parts of this effort for CLA was the development of a Spray Drift Database to provide Interim Drift Curves

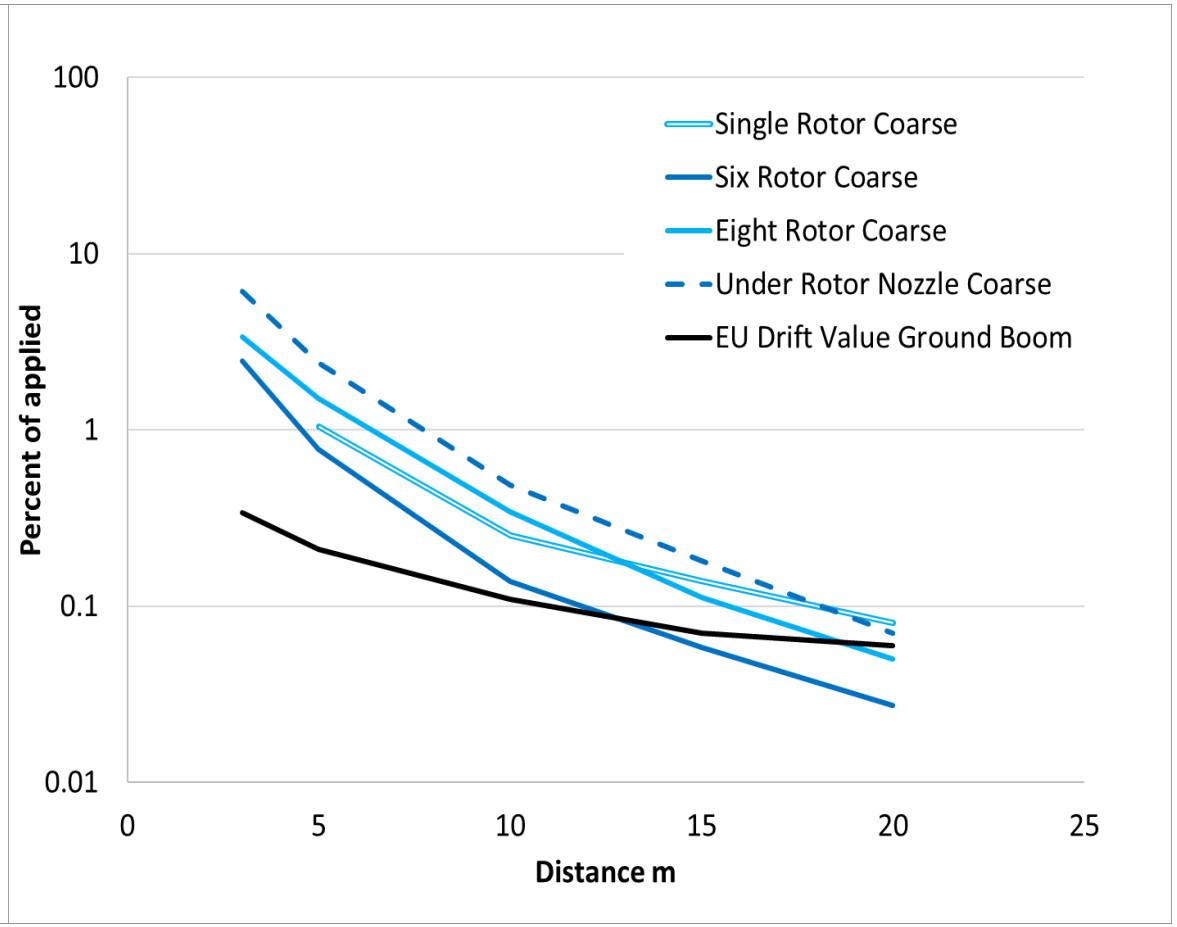
Spray drift data

- There are a number of spray drift studies but not many of them relevant to farming practices within the USA
- Three independent studies were identified that investigated relevant application rates and nozzles for spray drift reduction for US and EU agricultural systems
  - These studies returned similar results increasing our confidence in the data
  - Raw data was required and only two groups were able to provide this
- Comparisons of this data has been made between the basic drift curves for three separate regulatory bodies
  - EU: EU Ground, EU Orchard Airblast, EU Aerial,
  - EPA: AGDRIFT Ground, AGDRIFT Orchard Airblast, and AGDRIFT Aerial
  - PMRA: Wolf and Caldwell Ground Ganzelmeier Orchard airblast and Aerial AGDISP

Drift assessment with four different UASS operating at 2 m/s and 1.5 m altitude compared to the EU basic drift curve for Ground Boom sprayers.

Research conducted with Andreas Herbst (DE), Jane Bonds (USA), Changling Wang, and Prof He (CA)



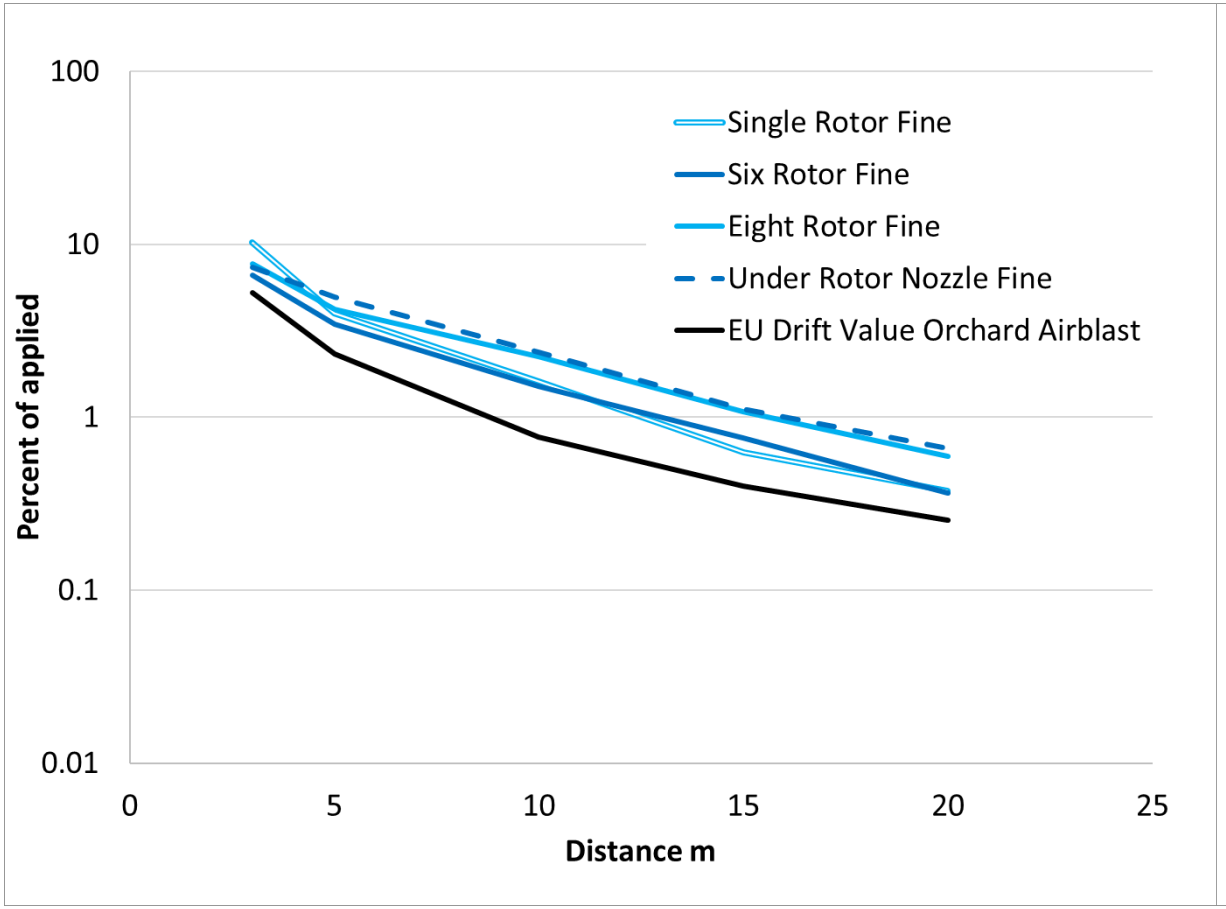


EU Tractor Boom Fine Nozzle

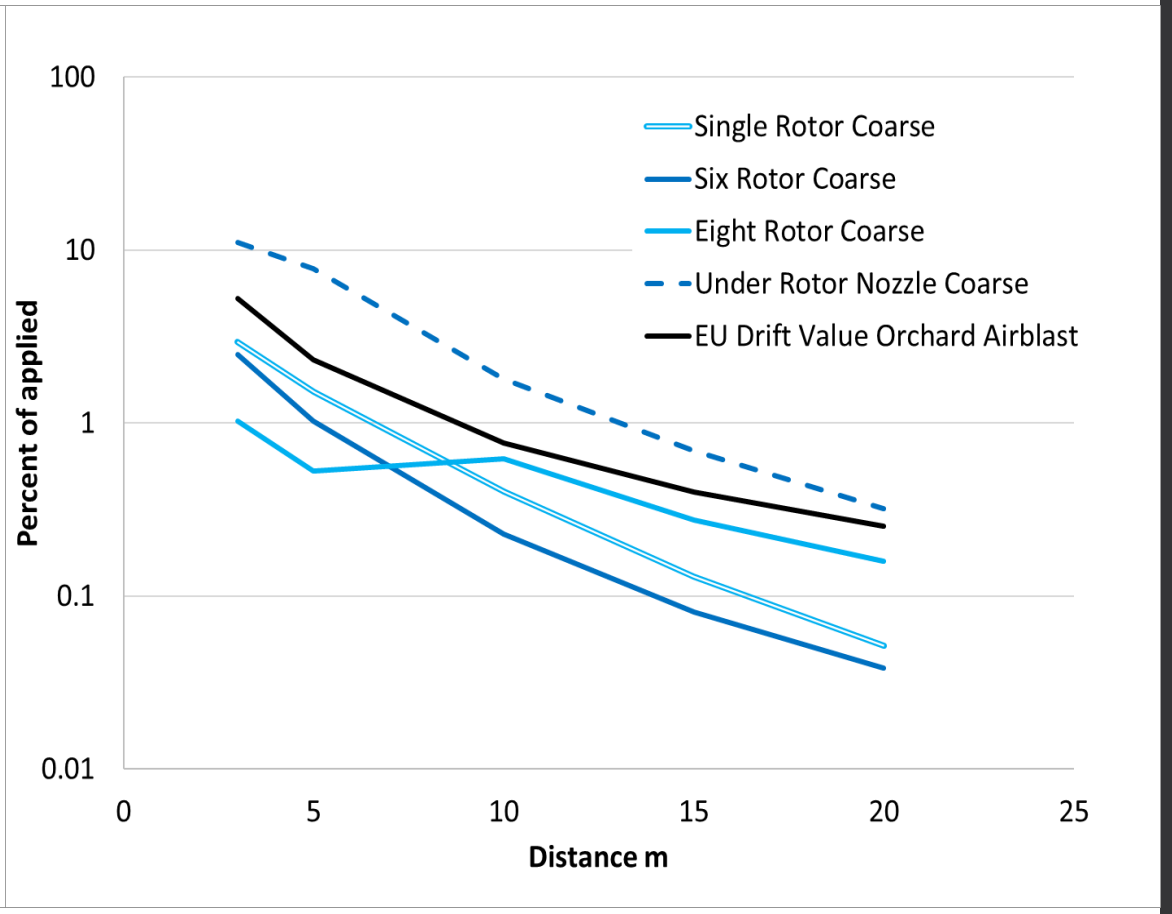
EU Tractor Boom Medium Nozzle

Drift assessment with four different UASS operating at 2 m/s and 3.5 m altitude compared to the EU basic drift curve for Orchard Airblast sprayers.

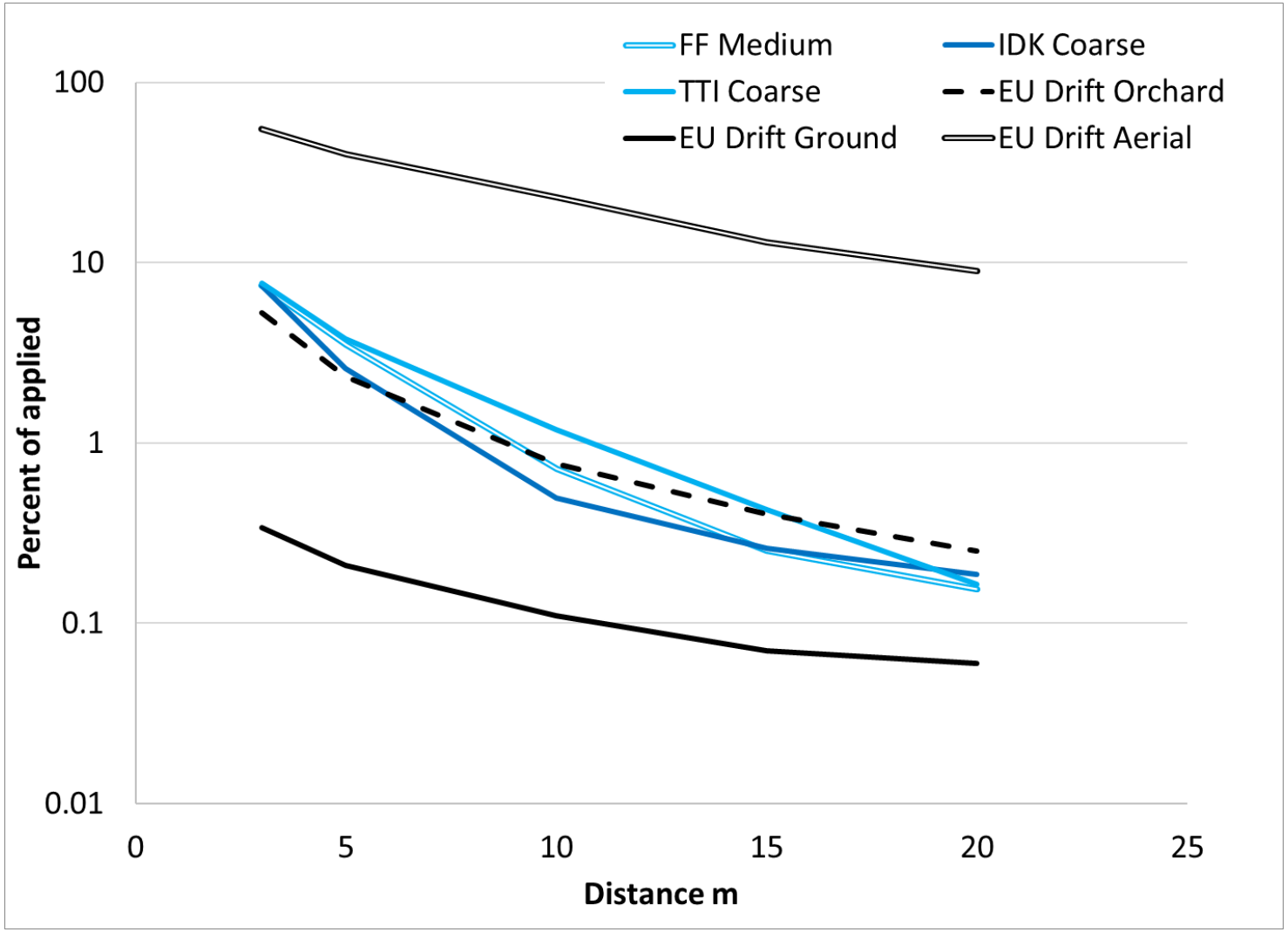
Research conducted with Andreas Herbst (DE), Jane Bonds (USA), Changling Wang, and Prof He (CA)



EU Orchard Airblast Fine Nozzle



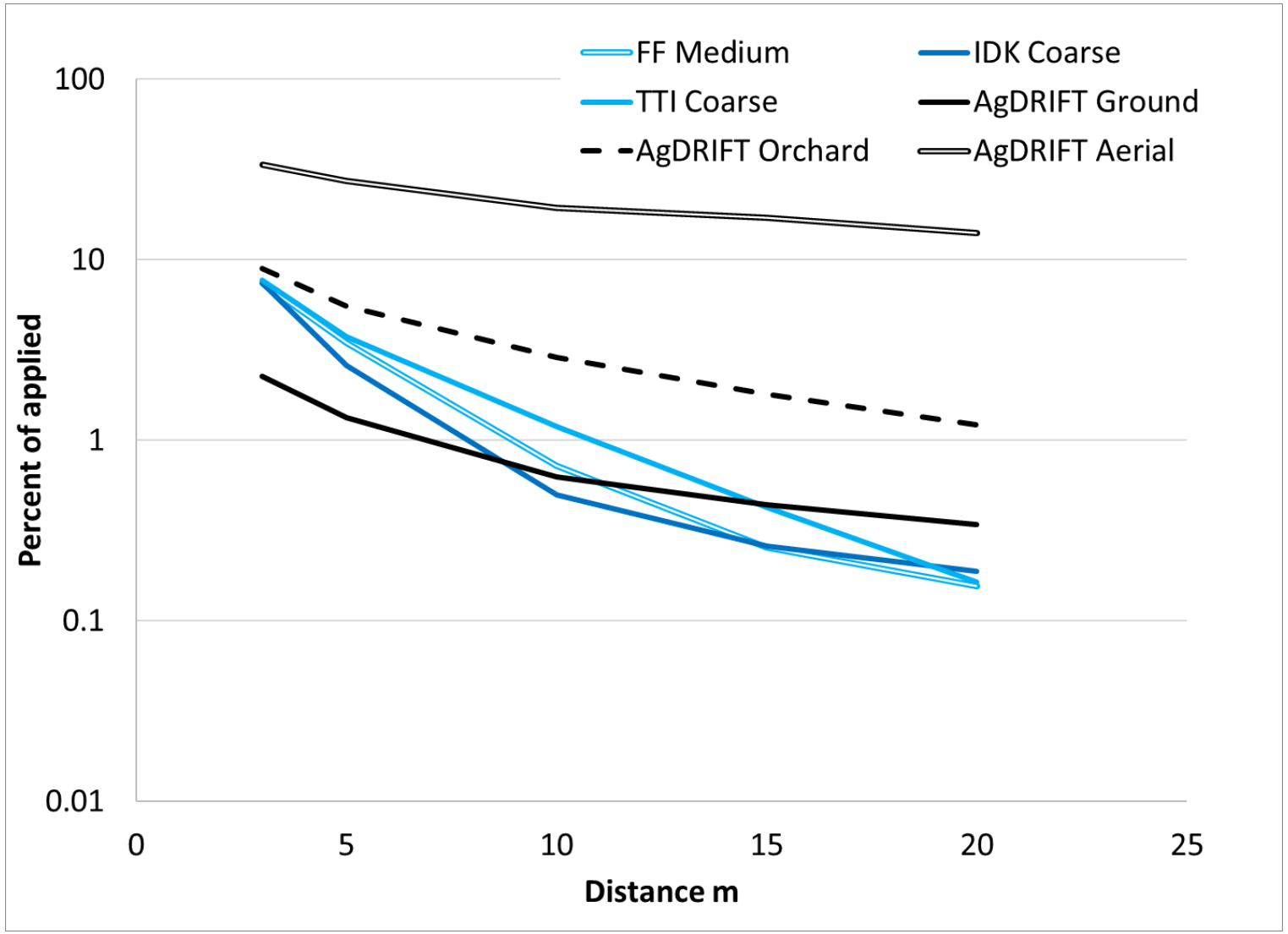
EU Orchard Airblast Coarse Nozzle



Drift studies conducted at 3.5 m and 3.5 m/s using a 6 rotor UASS with a medium and two coarse droplet size distributions

Compared to the EU Basic Drift Curves

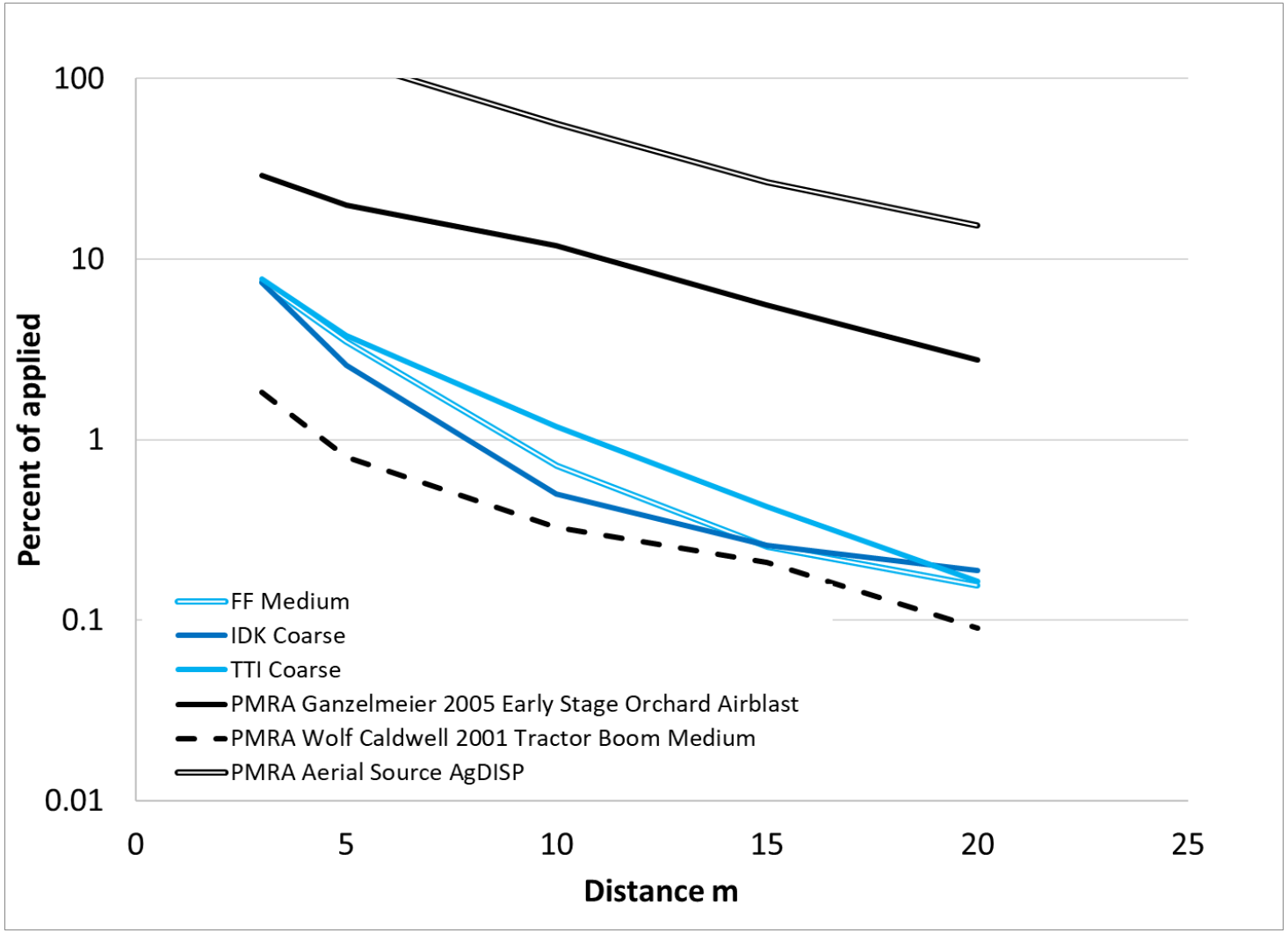
Research conducted by Jane Bonds, Brad Fritz and Harold Thistle



Drift studies conducted at 3.5 m and 3.5 m/s using a 6 rotor UASS with a medium and two coarse droplet size distributions

Compared to the EPA AgDRIFT 2.1.1 Orchard, Ground, and Aerial Curves

Research conducted by Jane Bonds, Brad Fritz and Harold Thistle



Drift studies conducted at 3.5 m and 3.5 m/s using a 6 rotor UASS with a medium and two coarse droplet size distributions

Compared to the Canadian PMRA Curves

Research conducted by Jane Bonds, Brad Fritz and Harold Thistle

Interim Curves from the Spray Drift Database

Initial indications support the assumption that from a spray drift perspective, UASS curves are somewhere between aerial and ground-based methodologies, comparing closest to orchard airblast applications, based on the published literature.

White Paper: Other key takeaways

Operator Exposure

- This literature review supported the consensus that during an application UASS have less potential for exposure compared to backpack sprayer
- Exposure of a UASS operator is possibly more to an operator sealed within the cab of an aircraft or tractor
- For other job steps such as mixing / loading where instructions for PPE are followed the exposures should be equal
    - Closed or 'near-closed' systems are not common

Picture taken fromYan, X.; Zhou, Y.; Liu, X.; Yang, D.; Yuan, H. Minimizing Occupational Exposure to Pesticide and Increasing Control Efficacy of Pests by Unmanned Aerial Vehicle Application on Cowpea. Appl. Sci. 2021, 11, 9579. https://doi.org/ 10.3390/app11209579

Crop Residues

- For UASS applicators following the label for conventional application techniques with the same rates, there is no evidence that concentration affects residues
  - This is important as this means there can be a reduction in water consumption
- For low volume formulations, such as Ultra Low Volume (ULV) products, it could be important to see if the residue profile differs from non-ULV formulations.

Efficacy

- Applications with UASS tend to be equivalent to conventional methods however, this field of study is still evolving for UASS and will likely depend on crop, target, product, local conditions, etc.
- These applications are conducted with lower total volumes than conventional techniques which leads to lower coverage of the target surface
- Several studies applied insecticides in conjunction with fungicides
  - The fungicides tended to show lower control than the conventional technique

Multiple platform types

- One of the challenges faced by researchers wanting to characterize the spray distribution from UASS is the large number of different platform types
  - Nozzle location
  - Nozzle number
  - Rotor number
- There are also multiple use categories and therefore application settings
  - Flight speed
  - Flight altitude
  - Application rate
  - Droplet size distributions

Parameter Database

- This data was accumulated into a parameter database with the aim to identify the most typical operating protocols
- The database contains descriptions of UASS platforms from 40 different manufacturers.
- The database records the author and year of each study alongside a brief description and a notation as to whether the study was relevant and reliable
  - Now the majority of systems are multi rotor. Single rotor systems could be modeled (AGDISP) but are difficult to operate
  - The most typical payload is 10 liters ranging up to 25 L
  - The number of systems with spray booms vs nozzles under the prop is approximately half and half
  - The average release height is 3 m but ranges from 1-6 m
  - The average forward speed is 3.5 m/s but ranges from 1-9 m/s

Funding Provided by the CLA Drones Working Group

- The Working Group's mission is to evaluate existing data that compares Uncrewed Aerial Spray Systems (UASS) with conventional methods of application to identify equivalencies and information gaps for UASS applications within a regulatory context
  - Industry White Paper : Uncrewed Aerial Spray Systems: spray drift, operator exposure, crop residue, and efficacy: equivalency with conventional techniques
  - Summary Presentation

Future Directions

Bonds Spray Drift Database Work

- Intention is to be public-facing: Providing an overall framework to help organize future drift research and to strengthen our knowledge base
- With continued interaction w/OECD Drone Subgroup via EPA/PMRA/BIAC

Further work with the Unmanned Aerial Pesticide Application System Task Force (UAPASTF)

- Following the milestones as outlined in work package #1 / off-site exposure OECD Drone / UASS Subgroup "Task and Finish" team

CLA Drones Working Group in General

- Support/Work/Advocacy for UAV Best Management Practices
- Eventually Label Language Support/Work

Continued interactions with CropLife Asia on research direction and methods, as one of the largest data generation groups