Trial conduct for UASS OTM studies and expansion of the spray drift database.

Unmanned Aerial Pesticide Application System Task Force (UAPASTF).

Ecological and Environmental Exposure

Jane Bonds

Naresh Pai

Database and Quality Criteria for UASS OTM Studies

- Ecological and environmental exposure (EEE) subgroup of the UAPASTF has updated information on off target movement (OTM) with unmanned aerial spray systems (UASS).
  - The EEE subgroup expanded and improved recommendations for the conduct of UASS OTM studies: Report on the UAPASTF website
    - The document amalgamates conventional standards to be specific to UASS
    - The document highlights UASS specific pitfalls
    - Provides methods to return reliable exposure estimates suitable for use in model validation.
  - The EEE subgroup update the OTM database developed for CropLife America (CLA) Drone Working Group (DWG).

Off Target Measures

Methods Development for UASS

Spray Drift Trial Methods from Standards

- Within the methods document each section is introduced using examples from ISO, ASABE, EPA, and SETAC DRAW standard documents.
- These provide a framework that has been modified with measures specific to UASS.
- UASS literature was used to highlight how studies succeed and fail to return reliable data.
- Solutions are provided to avoid UASS specific ambiguities and outline methods that can help address unknowns.

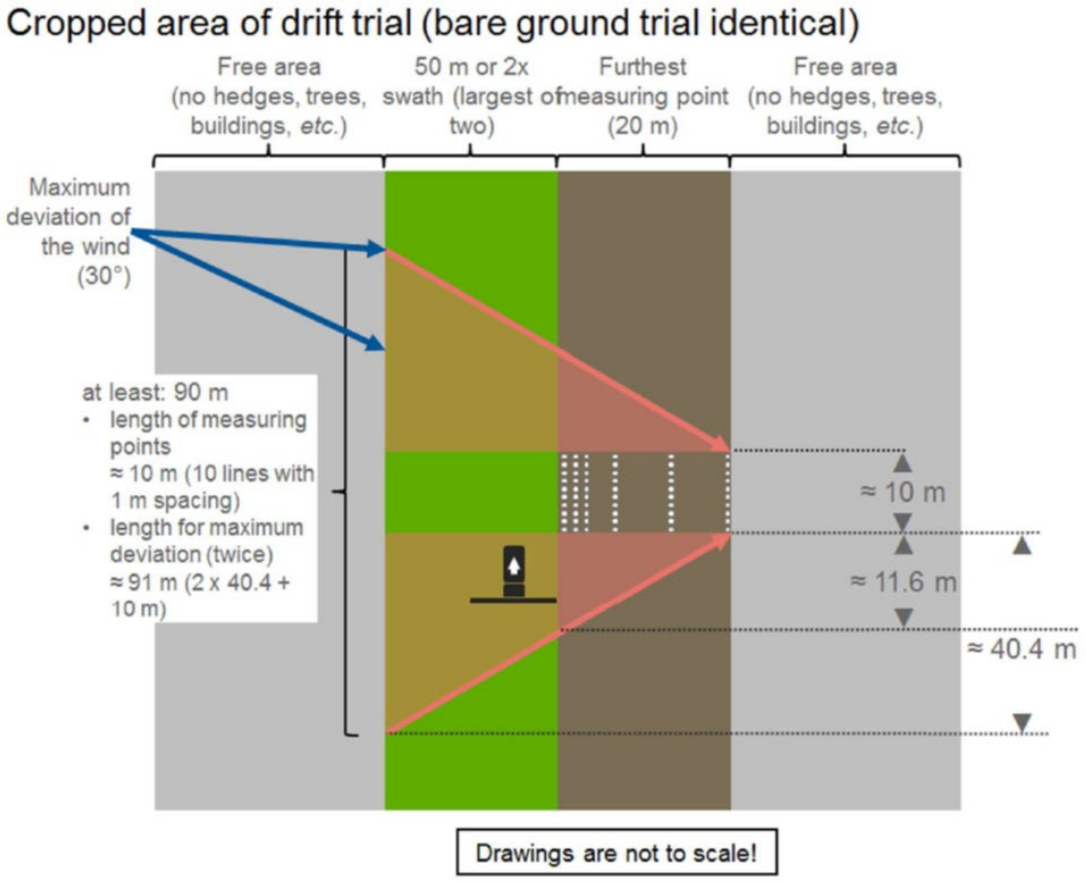

Welcome to
Unmanned Aerial Pesticide
Application System Task Force.
Report
https://uapastf.com/

Examples from Standards

- Three replicates is a widely adopted minimum that meets basic statistical requirements for estimating variance, Preferred >10 replicates
  - 12 out of 26 studies had one replicate
- Horizontal sampler mylar, petri dish or filter paper, suggested 100 cm^2 mylar card. Vertical samplers not required, recommended distance of 5 m EoF recommented no lower than 1 m upto 2m above flight height.
- Equipment effects, no crop, bare ground with vegetation heights/stubble < 7.5 cm, with one pass.
- Operational practices, crop should be representative of spraying growth stage, with multiple passes
- The weather reporting, sample handling, analytical techniques etc, are not UASS specific.

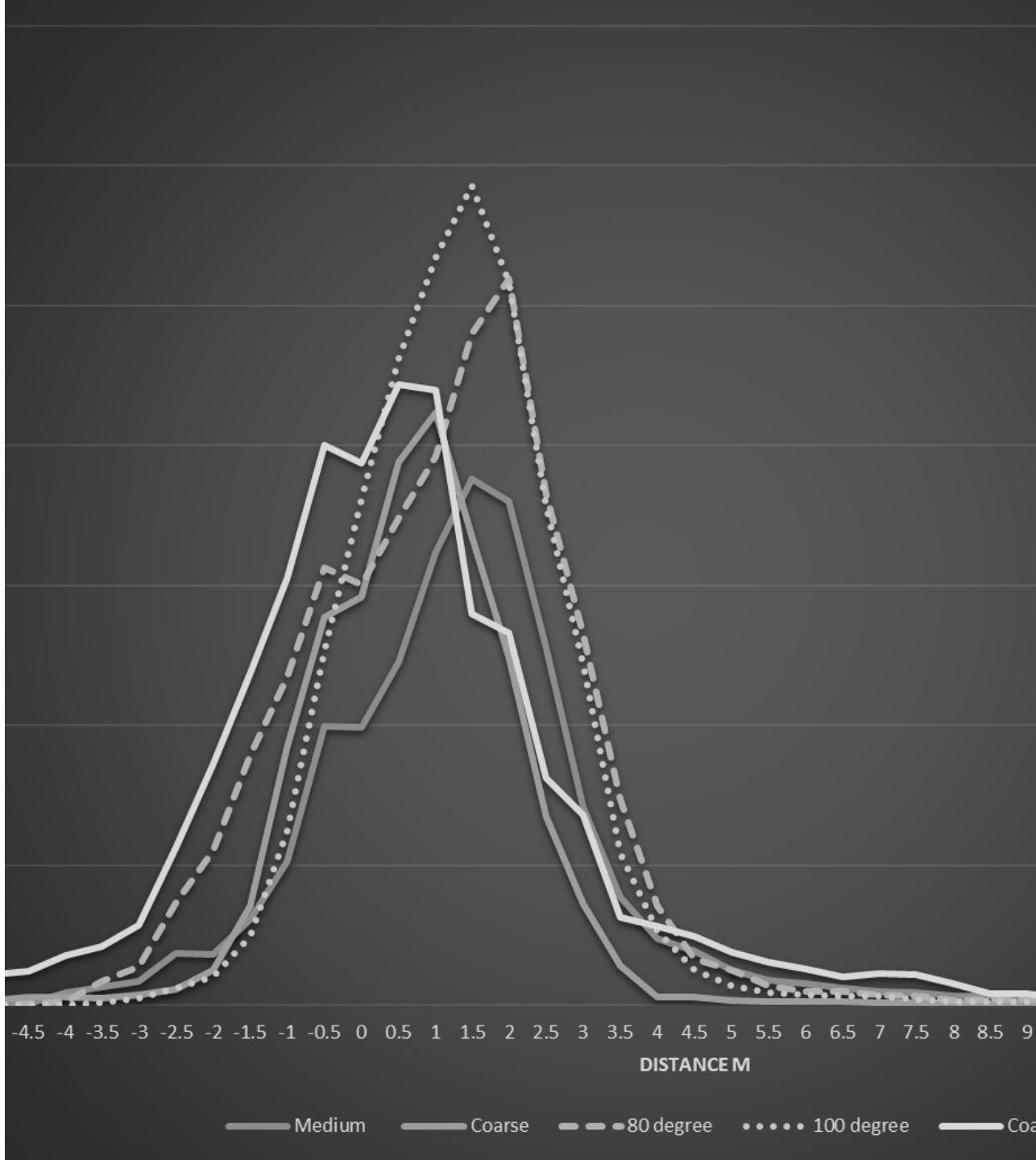
Typical trial layout

- Open area, minimal obstacles and slope
  - Clear for 10 x the size of the test area
- Sample line length
  - 20 m EU and 35-300 m USA standards
- Width of sprayed area
  - ISO 20 m or the swath width of the sprayer
  - SETAC 50 m or 2 x the swath whichever is larger.
  - EPA whole field.
- Length
  - The length of the treated area should be enough to capture drift at the furthest sampler; with a tolerance for wind direction shifting up to 30° from perpendicular



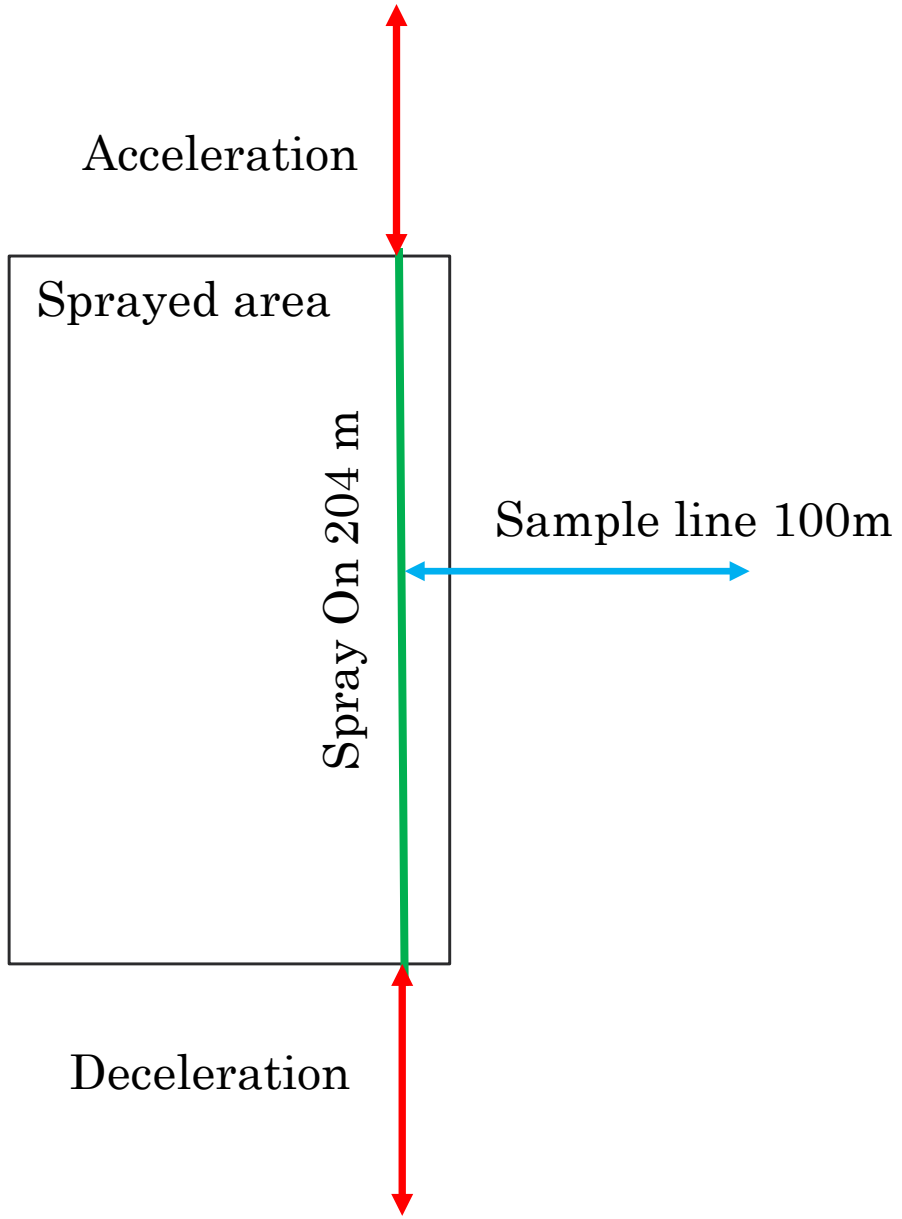
Sample Line Length

- ISO: the average distance where 90% of the deposit has been collected was 12 m, there were 5 studies with a drift distance > 20 m.
- Database: two research groups went to 100 m, with detectible deposits at that distance
- One 100 m is the recommended sample line length for orchard airblast ASABE
- There should be a minimum of 10 collection distances



Spray Line

- Few studies speak of the spray line instead the size of the sprayed area
- Spray line is 2x the sample line to be less sensitive to wind shifts, plus the distance between subsample lines. For 100 m with three lines of sampler spaces 2m apart 204m.
- Speed has a significant effect on drift therefore must be maintained.
- The length of the spray line must include acceleration and deceleration.
- Spray on at field edge

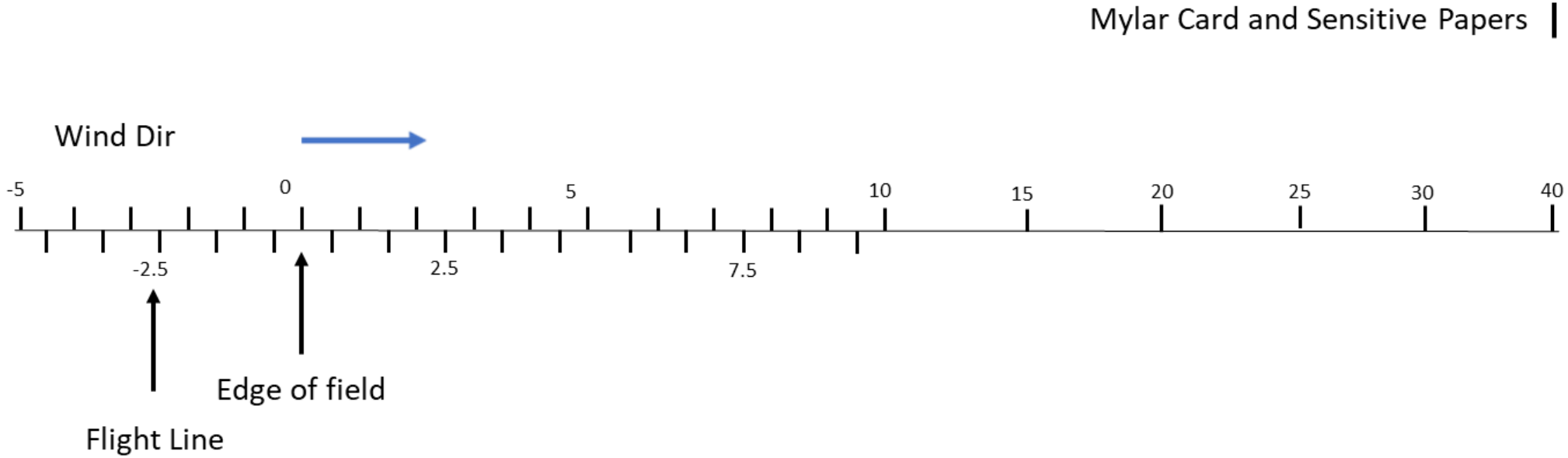


Swath Width

- The volume deposited within the swath when measured is typically less than nominal
- Studies have checked speed and flow rate, leaving swath width
  - Enlarged swaths for logistical efficiency
  - Cross wind offsetting
  - Too few samples
- But the numbers are quite large
  - Brown Giles 58 %
  - Martin 45 and 57 %
  - Buttler-Ellis 56 %

Sampler position

- The edge of field is half a swath width downwind of the flight line
- Swath width is difficult to define and especially with a cross wind
- A measure of rate applied to accurately calculate % of applied the whole profile should be measured
- If the whole profile approach is not adopted the distance to the first sampler should be 3 m to reduce near field overspray



Calibration

- The role of a sprayer is to deliver the required does to the target.
- There needs to be manual checks:
  - The volume sprayed
  - The speed
  - The length of the spray line
  - The altitude.
- Altitude should be recorded from the ground (AGL) including the height of the vegetation

The report is currently being prepared as a paper.

Empirical Data
Off Site Movement Database

Database

Read Me: The various descriptive parameters.

Trial Info: Is a general description of the experiment and assigns a numerical descriptor.

Trial conduct: Provides detailed descriptions of the experimental set up and associated meteorological conditions for each trial.

The replicate data has been grouped by researcher with data interpolated to fit the distances used by Herbst for comparison.

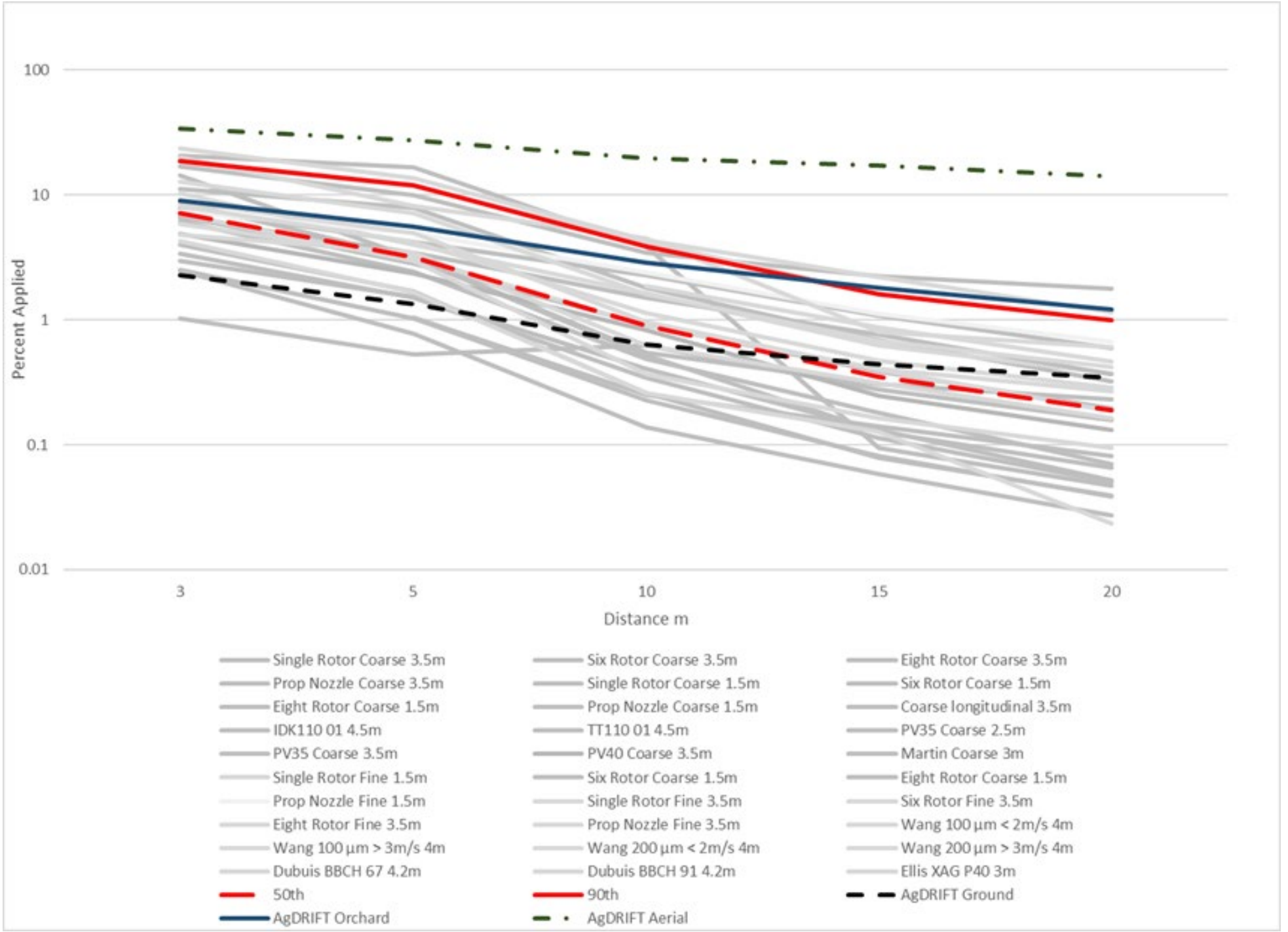
Parameter	Units	Explanation
variant		serial number of tested variant
replicate		serial number of the replicate for each variant
Trial Information		**Basic informatio on the trial**
Principle investigator		primary contact for the conduct of the trial
Country		location by country
Date	mm/dd/yy	the date that the treatment was applied
Time	hh:mm	sampling time of the wind data
Description Notes		Identification of the primary treatment parameters
Location	decimal degrees	name of site or coordinates wher the tests were conducted
Trial Conduct		
Crop type		desription of the vegetation type present
Growth Stage	**BBCH**	average phenological stage of the vine canopy according to the BB
Crop Height cm	cm	average height from the ground to the top of the vines rows
Number of rows sprayed		number of flightlines
Sampler type		type of deposition sampler
Sampler height	cm	height of the deposition surface from the ground
Sampler size	cm2	size of the deposition sampler surface
Flight line direction		orientation of the flight lines relative to the orientation of the crop
Equipment data		
Manufacturer		the name of the manufacturing company
UASS Name		Name of the version of UASS used
Rotor number		Number of rotors on the UASS
rotor width	cm	the diameter of the individual rotors
Total rotor width tip to tip	cm	the diameter of the rotor assembly on the UASS
Weight of the aircraft	kg	weight of UASS unloaded
Gross weight	kg	weight of UASS fully loaded
Nozzle type		manufacturer and type of the nozzle the UASS was equipped with
Drop size category		ASABE droplet size category
Nozzle number		number of nozzles at the UASS
Nozzle separation	cm	distance between each nozzle if it is the same
Nozzle location horizontal	cm	location of each nozzle on the boom if the nozzle spacing isnt equa
Nozzle location vertical	cm	distance of the nozzles or boom vertically from the centerline of th

Trial Info | Trial Conduct | Platform | Met data | Rep data Herbst | Rep

Database

- Herbst et al., and CAU data on simulated arable and vineyard, four platforms, and droplet size (20m).
- Herbst/Glasser et al., data on sloped vineyards with combinations of platform, flightline position, and droplet size (20m).
- Bonds/Fritz et al., bare ground data on three different platforms, flight altitude, boom position, and droplet size (40m and 100m).
- Martin/Tang (Bayer) UASS vs conventional arable, and droplet size (100m).
- Dubuis et al., data on bystander exposure with two different orchard growth stages (40m)
- Buttler Ellis et al., Bare ground multiple pass system check (50m)

Manufacturer	Model	Rotors	Weight kg	Nozzle	Application Height m	Travel Speed m/s
Leading Edge	PV35	6	34	FF 110 03	3.5, 2.5, 4.5	3.5
				AI 110 02	3.5, 2.5	3.5
				TT 110 01	4.5	3.5
				IDK 110 01	4.5	
	PV22	4	24	FF 110 03	3.5	3.5
				AI 110 02	3.5	3.5
				TT 110 01	3	3
				TTI 110 01	3	4
	PV40	6	52	FF 110 03	3.5	3.5
				AI 110 02	3.5	3.5
				DG 110 04	3.5	3.5
				DG 80 04	3.5	3.5
DJI	Agras MG1	8	22.5	TR 80 0067	3.5, 1.5	2
				IDK 120 015	3.5, 1.5	2
Beifang Tiantu	3WTTAB-20	8	26	TR 80 0067	3.5, 1.5	2
				IDK 120 015	3.5, 1.5	2
TTA6	TTA 6	6	21	TR 80 0067	3.5, 1.5	2
				IDK 120 015	3.5, 1.5	2
Anyang Quanfeng	3WQF80-10	1	59	TR 80 0067	3.5, 1.5	2
				IDK 120 015	3.5, 1.5	2
Multikopter	EVO-X8	8		ATR brown	3	2.1
DJI Agras	MG 1S	8	24.8	Airmix110015	4, 3	1.5, 2.5
				IDK 90 025	3	2.5
				XR 110 01	4, 3	2.5
DJI Agras	T16	4	16	IDK 90 025	4	3.5
				XR 110 01	4	2.6
DJI Agras	T30	6	76.5	XR 110 02	4.2	2


100
10
1
0.1
0.01
Percent Applied
3
5
10
15
20
Distance m
Single Rotor Coarse 3.5m
Six Rotor Coarse 3.5m
Eight Rotor Coarse 3.5m
Prop Nozzle Coarse 3.5m
Single Rotor Coarse 1.5m
Six Rotor Coarse 1.5m
Eight Rotor Coarse 1.5m
Prop Nozzle Coarse 1.5m
Coarse longitudinal 3.5m
IDK110 01 4.5m
TT110 01 4.5m
PV35 Coarse 2.5m
PV35 Coarse 3.5m
PV40 Coarse 3.5m
Martin Coarse 3m
Single Rotor Fine 1.5m
Six Rotor Coarse 1.5m
Eight Rotor Coarse 1.5m
Prop Nozzle Fine 1.5m
Single Rotor Fine 3.5m
Six Rotor Fine 3.5m
Eight Rotor Fine 3.5m
Prop Nozzle Fine 3.5m
Wang 100 µm < 2m/s 4m
Wang 100 µm > 3m/s 4m
Wang 200 µm < 2m/s 4m
Wang 200 µm > 3m/s 4m
Dubuis BBCH 67 4.2m
Dubuis BBCH 91 4.2m
Ellis XAG P40 3m
50th
90th
AgDRIFT Ground
AgDRIFT Orchard
AgDRIFT Aerial

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