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SuproFruit 2023

Developments/advancements in spray application

Gideon van Zyl

Hortgro Technical symposium 2024

INRAE IFV CTIFL SUDEXPÉ ECOTECH WAGENINGEN UNIVERSITY & RESEARCH eufrin

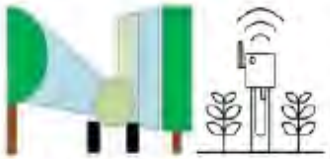
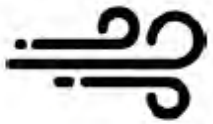
— EUROPEAN FRUIT RESEARCH INSTITUTES NETWORK —

SuproFruit 2023

16th Workshop on Spray Application and Precision Technology in Fruit Growing

19 – 21 September 2023

Program – 45 presentations 3 days

	Session 1: Precision Technologies, Crop Sensing and Precision Spray Application
	Session 2: Spray Cover and Deposition
	Session 3: Spray Atomization, Air Support, New Technologies (incl. Drones) for Spray Application
	Session 4: Spray Drift
	Session 5: Environmental and Operator Safety related to Fruit Crop Spraying

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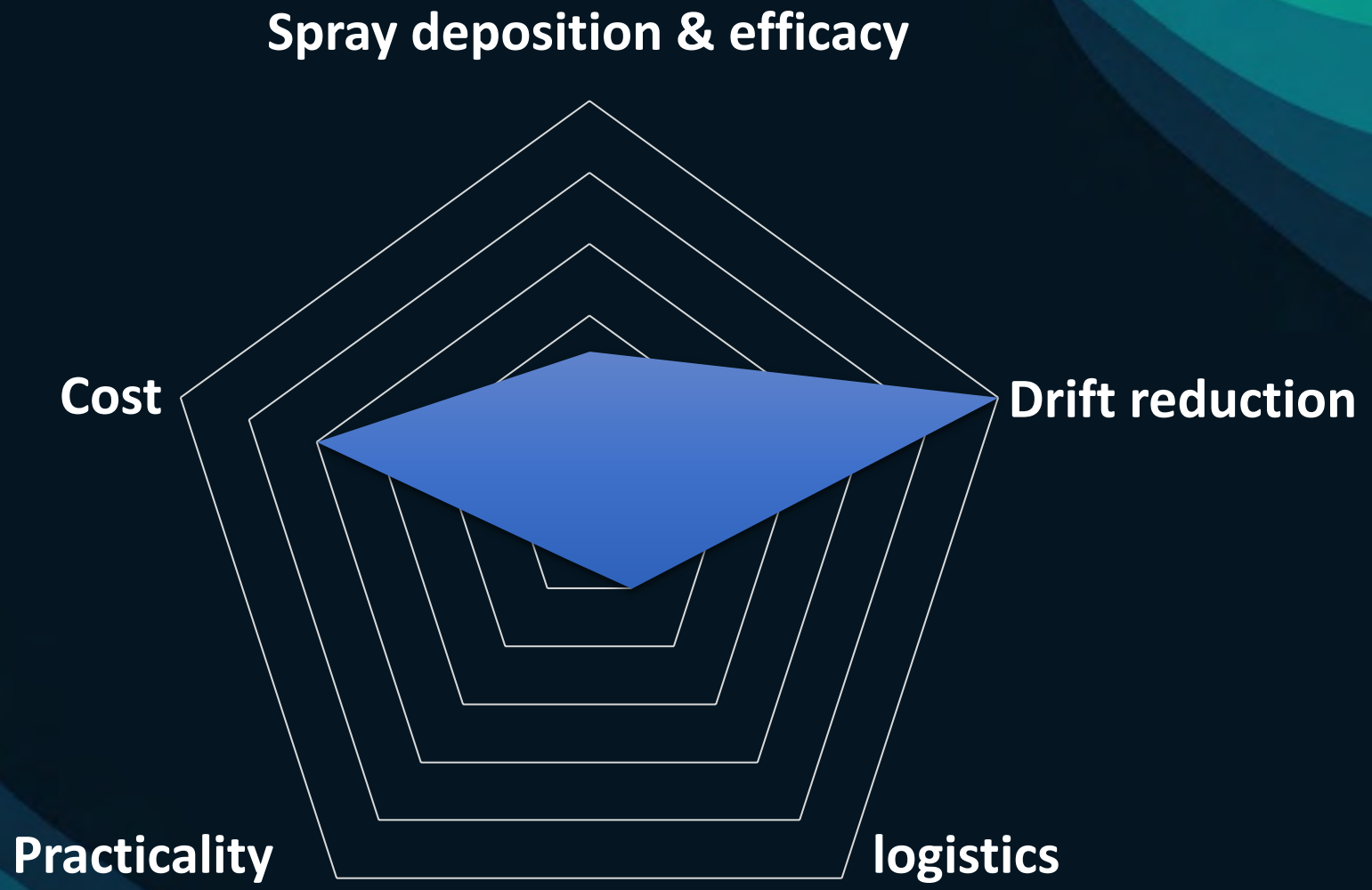
Development/advancement in spray application is in the eye of the beholder



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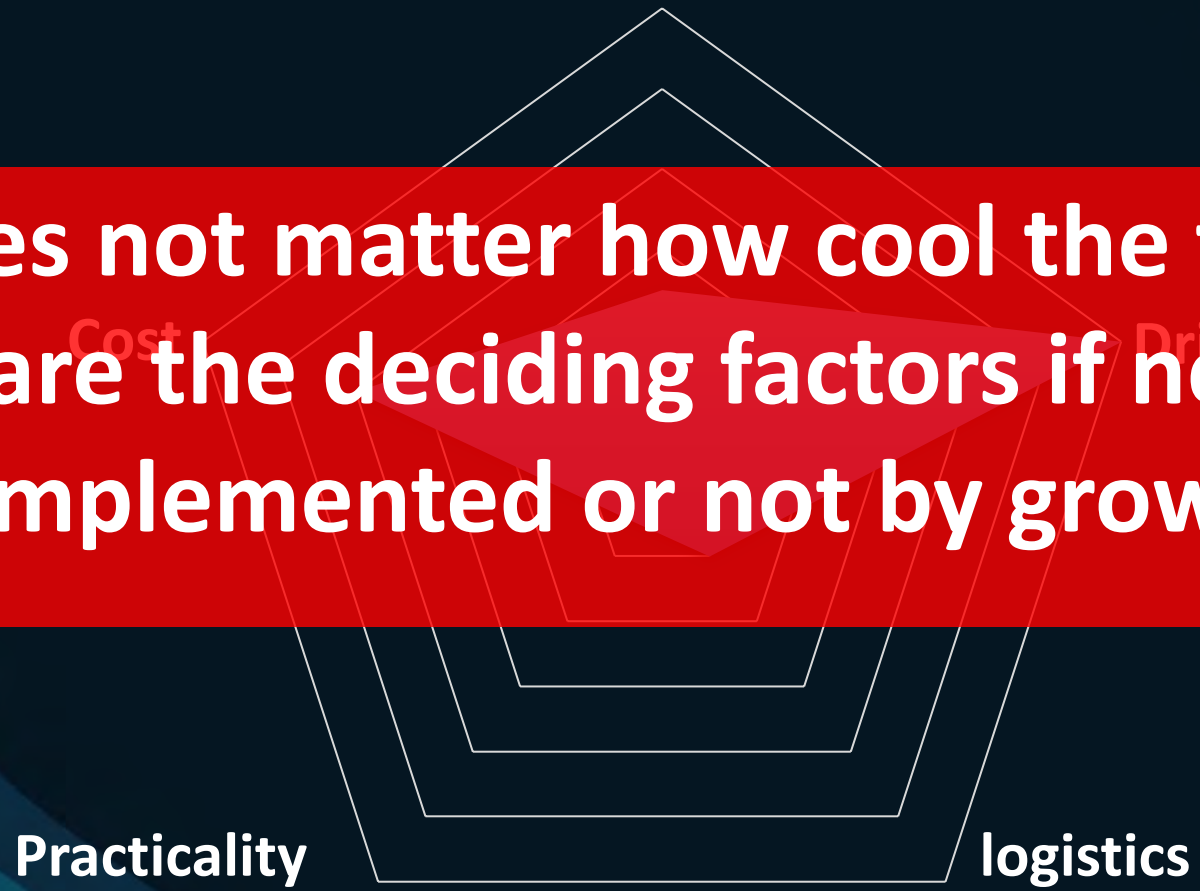
Development/advancement in spray application is in the eye of the beholder



It does not matter how cool the tech is…
These are the deciding factors if new tech is implemented or not by growers

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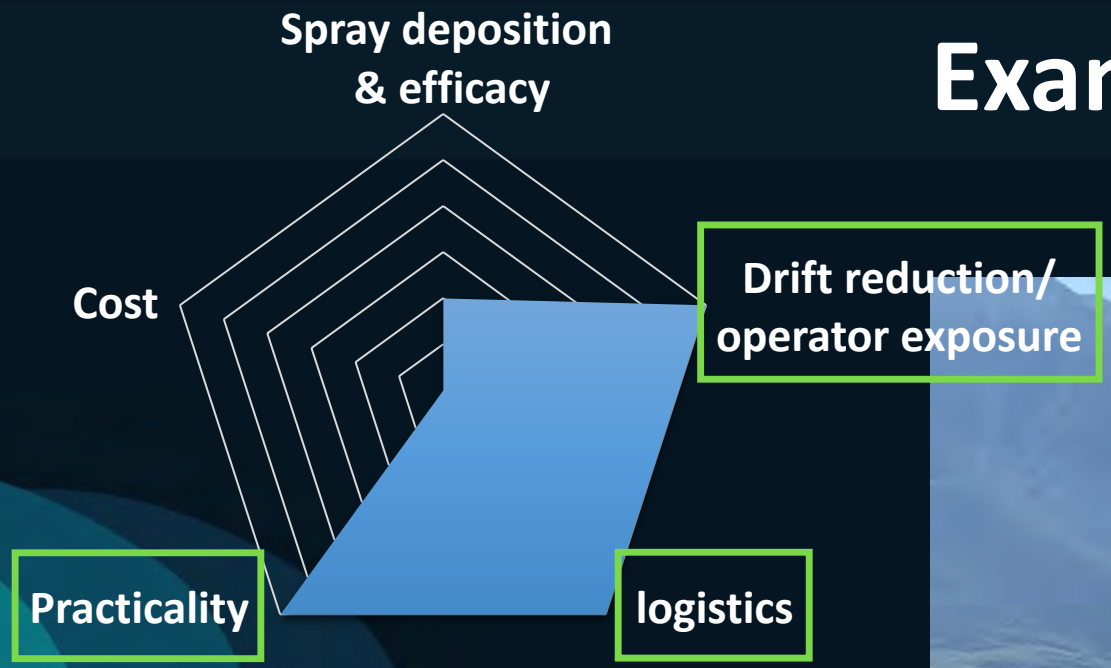
Example: UAVs



Wy are UASS used in Switzerland?

- Mountain regions with **steep slope fields** that are difficult to spray
- **UASS**: unmanned aerial spraying systems as a **useful solution**
- **Alternative** to **hand held** and **backpack** sprayers and **helicopters**

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Example: UAVs – It ticked the boxes..

Return on Experience on the use of UASS for plant protection application. The case of on crops grown on steep slopes in France.

Jean-Paul DOUZALS[1], Xavier DELPUECH[2], Guilhem POUXVIEL[1]

[1] INRAE UMR ITAP, Université de Montpellier, France

[2] Institut français de la Vigne et du Vin, Montpellier, France

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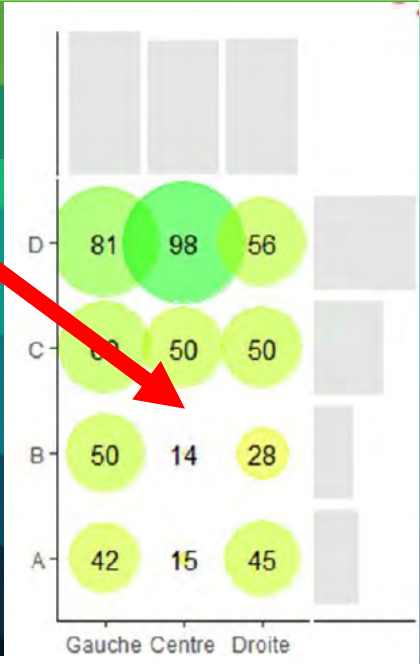
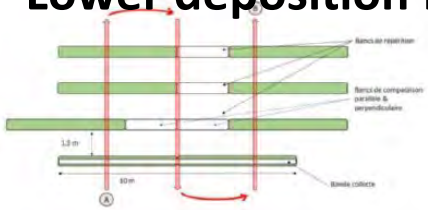
- 7 times lower spray deposition than with conventional spray application bunch zone
- Poor efficacy

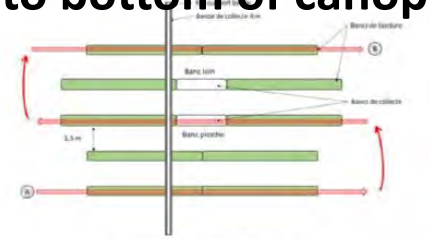


- Not practical for individual farmers due to EU legislation to operate own UAVs

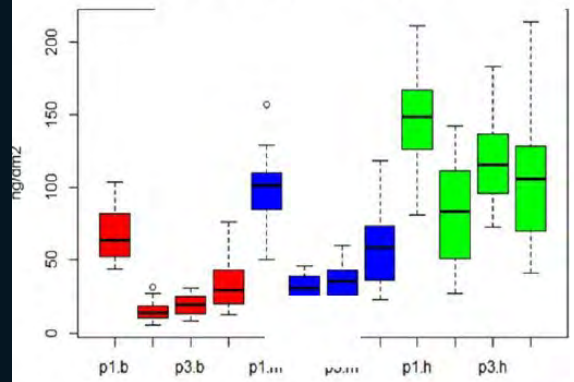
Lower deposition from top to bottom of canopy

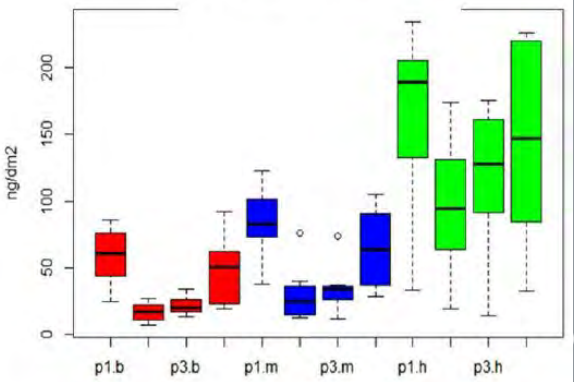


Perpendicular flight



Parallel flight





- Drift potential & operator exposure
  - Operator dermal exposure 200 times less than handheld applicator
  - Off target drift significantly less than helicopter and conventional applicators
  - Less noise pollution
  - Higher exposure to bystanders within 5 m
- Logistically UAVs easier to use

What advancements are applicable to our scenario?

Advancements that can improve:

1. **Correct sprayer selection**
2. **Improve logistical throughput without compromising spray deposition**
3. **Prepare our growers for drift mitigation legislation possibly impacting exports to sensitive markets**

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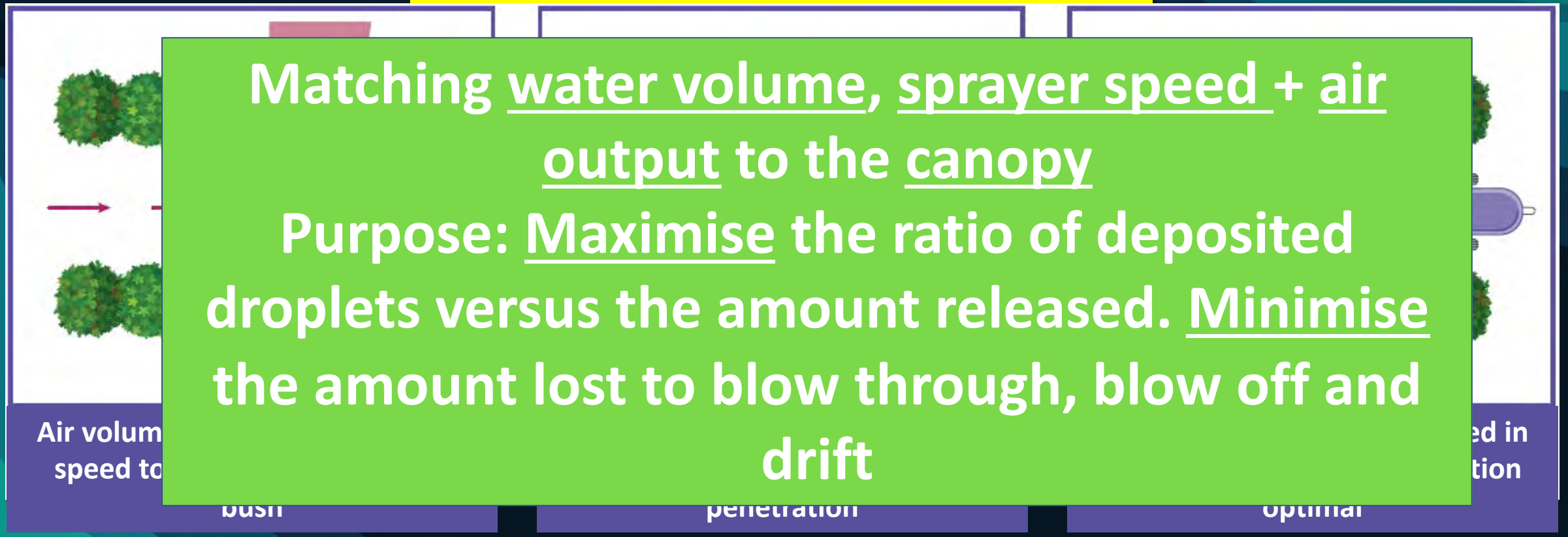
Most important development/advancement in application to date is understanding & implementing

Canopy Adapted Spraying



Matching water volume, sprayer speed + air output to the canopy

Purpose: Maximise the ratio of deposited droplets versus the amount released. Minimise the amount lost to blow through, blow off and drift

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Canopy Adapted Spraying

Precision spray application in fruit growing: recent and future issues

SuproFruit2023, 19 September 2023, Montpellier France

Jan van de Zande

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Introduction of Crop Adapted Spraying

- Sensing of the crop status / density
- Decision taking on the spray volume
- Actuating for the right application rate
- Based upon the knowledge of ?
  - Precispray *1999-2003*
  - CASA sprayer from EU project ISAFRUIT *2006-2010*
  - *KWH-CDS sprayer 2010-2013*
  - *H.S.S.-CF-ISA Precision Sprayer 2019-2020*

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Target Adapted Dosing and Spray Application in 3D Crops in Relation with the Official German System

Peter Triloff
Marktgemeinschaft Bodenseeobst eG

Target adapted dosing and spray application in 3D Crop in relation with the official German system
Target adapted dosing and spray application

Target Adapted Dosing & Spray Application: What are the components?

1. **Cross flow fan types with a low angle of the air flow (≤ 40°) and proven adjustability (General AirCheck®-certification, White List)**
   a) Spray deposition is improved by fan design
   b) Spray drift is allready reduced by design
   c) AirCheck®-certification guaranties suitability for canopy adapted spray application
2. **Adjustment of the air and liquid distributions to the farm specific orchard requiring the highest angle of the air flow (Personal AirCheck®-certification)**
   Enables spray application at canopy width adapted fan speed and forward speed of the individual fan
3. **Hollow cone nozzles (ATR purple) for quantitatively and qualitively efficient deposition of pesticides**
   a) Enables control of the horizontal reach of the spray mist by the air flow and forward speed
   b) Increases spray deposition efficacy by up to 40%
4. **2 x 2 „01“- ISO anti drift nozzles at the two top most nozzle positions**
   4 fan types officially registered in 75% drift reduction class. Potentially spray drift drift reduction > 90% at low water volumes;
5. **The AOS43 dosing model for canopy adapted dosing and spray application in 3D crops (forward speed, fan speed, water volume, dose rate)**
   The AOS43 dosing adapts 4 parameters (dose rate, water volume, forward speed, fan speed) to the 3 dimensions of 3D-crops.
6. **Training of operators**
   a) Theoretical and practical training
   b) Ev. correction of the tree height
7. **Cooperation with sprayer manufacturers**
   a) Annual technical workshop

Canopy Adapted Spraying

Implementation of new/tech/advancements in spray application is moot if CAS is not implemented

efsa EUROPEAN FOOD SAFETY AUTHORITY

GENERALITAT VALENCIANA ivia Institut Valencià d'Investigacions Agràries

Spray technologies in 3D crops in Southern Europe: a state-of-the-art survey

Patricia Chueca[1], Jaime Mata[1], Marco Grella[2], Marco Resecco[2], Konstantinos P. Ferentinos[3], Giovanna Azimonti[4], Cruz Garcerá[1]

[1]*Instituto Valenciano de Investigaciones Agraria / Centro de Agroingeniería (Valencia, Spain)*
[2]*Università degli Studi di Torino / Dept. of Agricultural, Forest and Food Sciences (Turin, Italy)*
[3]*Hellenic Agricultural Organization "DIMITRA" / Dept. of Agricultural Engineering (Athens, Greece)*
[4]*International Centre for Pesticides and Health Risk Prevention (Milan, Italy)*

ICPS DISAFA ivia Institut Valencià d'Investigacions Agràries SWRI

CONCLUSIONS

efsa EUROPEAN FOOD SAFETY AUTHORITY ICPS DISAFA SWRI GENERALITAT VALENCIANA ivia

- Current scenary:
  - Old sprayers and not well maintained
  - Efficacy is the most important topic
  - Precision application is not been adopted
  - Knowledge about drift but not much use of SDRT
- More formation and training is necessary to improve/change this scenary
- More efforts have to be done to transfer the innovations and technology

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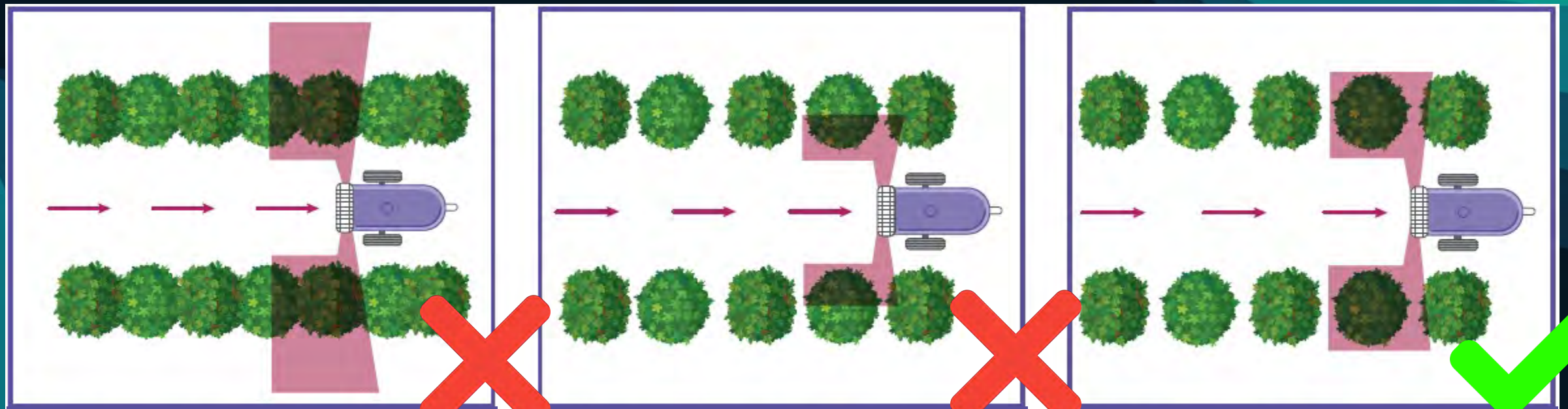
Canopy Adapted Spraying (CAS)



Air volume/speed too high, spray speed too slow, blows through bush

Air volume/speed too low, spray speed too fast, poor canopy penetration

Air volume/speed, spray speed in equilibrium, canopy penetration optimal

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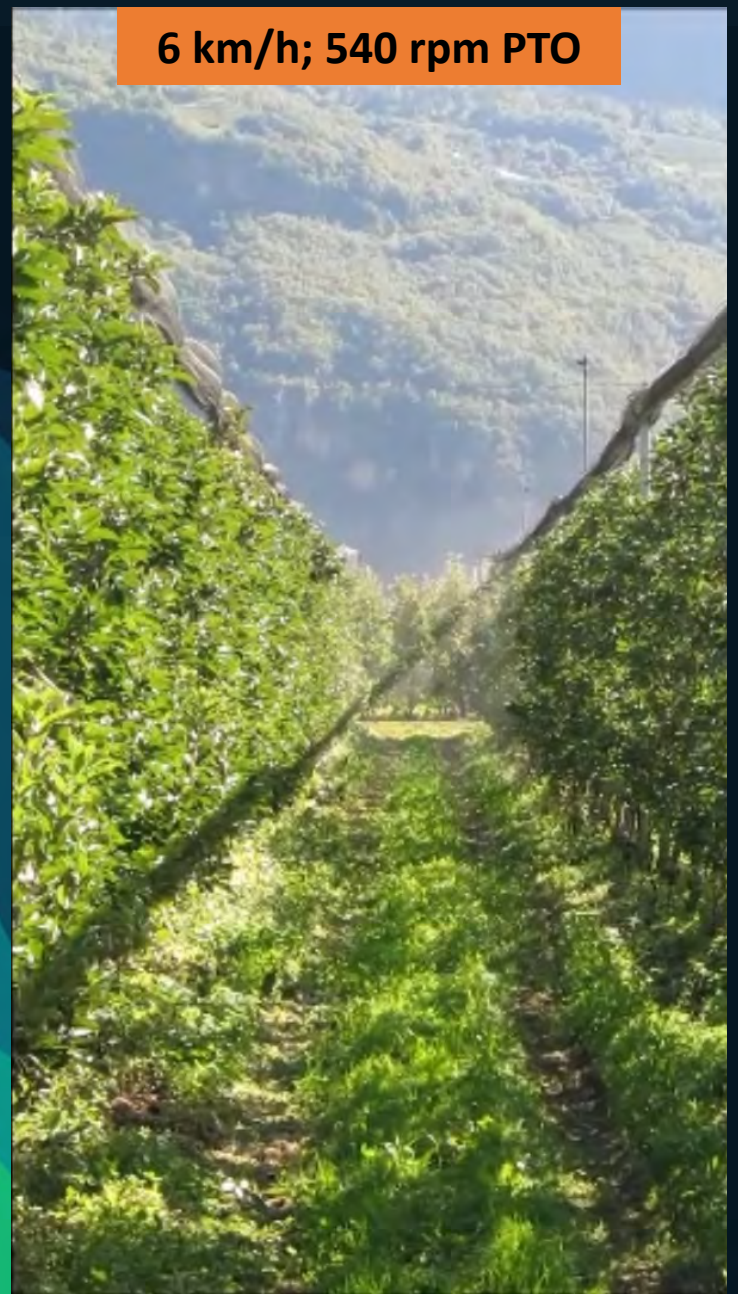
Canopy Adapted Spraying (CAS)



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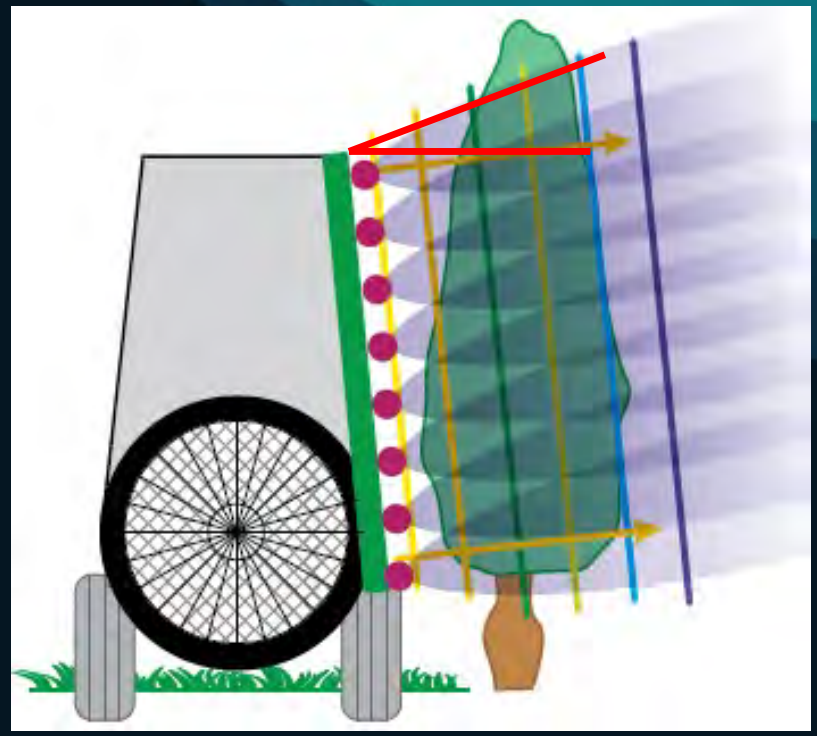
Sprayer choice (CAS)

- Mission > Load droplets into an airstream > carry droplets into & onto target > to be intercepted with minimal resistance and losses

- The sprayer must not remove deposited droplets from the target
  - (The fan is not an air-force)

- Sprayer air volume and profile must match canopy volume and profile

- The angle of airflow must be as low as possible in relation to the top of the canopy.



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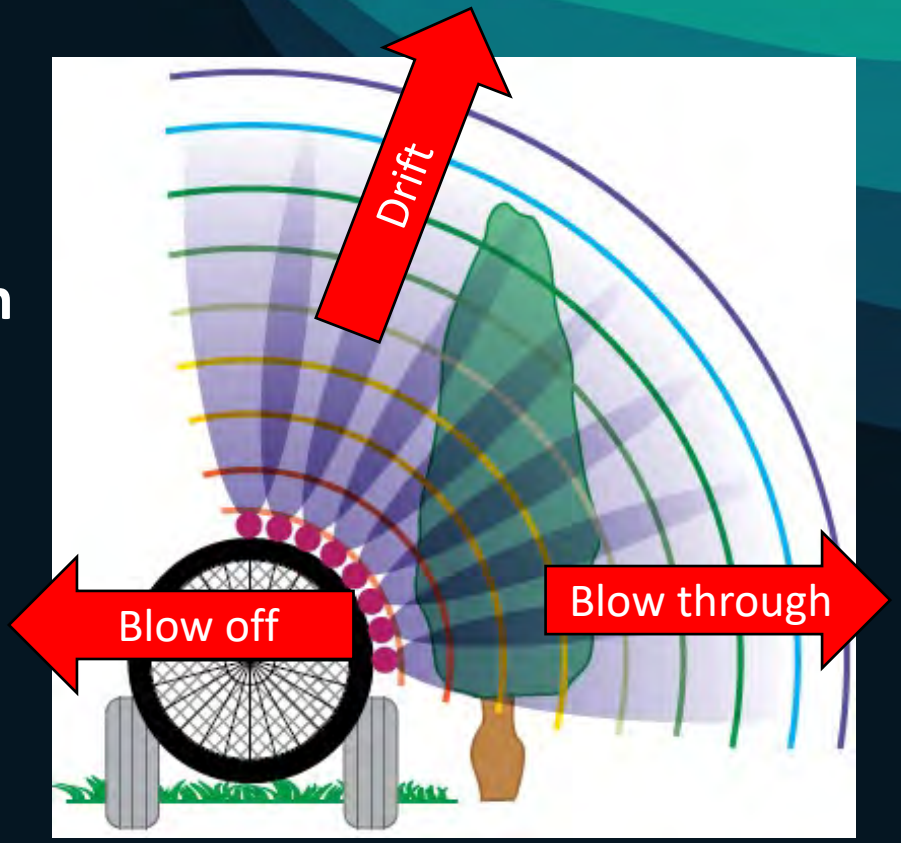
Sprayer choice (CAS)

- The angle of airflow must be as low as possible in relation to the top of the canopy (less than 40%)
  - Lower working height
  - Low deposition quality & high variation in deposition uniformity
  - High air volume/speed needed to reach top of trees
    - Excessive spray drift
    - Blow off and blow through
    - High energy cost



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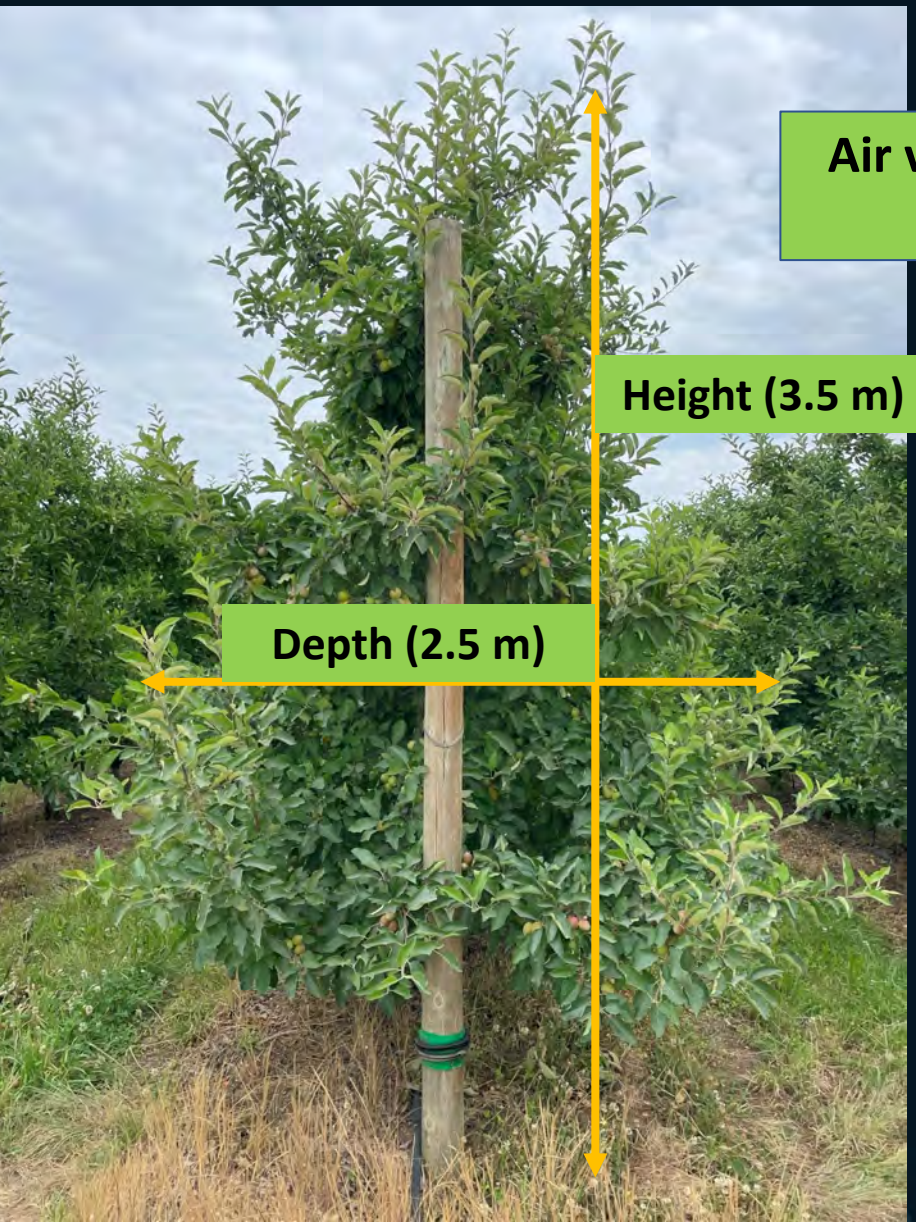
Sprayer choice (CAS)



- Calculate air volume needed:

Air volume needed (m^3/h) = Sprayer speed (km/h) × tree height (m) × width (m) × 1000

- Theoretical speed? 5-6 km/h?

- Air volume needed = 43 750 m3/h

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Advancements that can assist in CAS
Assisting the grower to choose the right sprayer

PERFORMANCE PULVÉ®

Objectives

- Classify sprayers according to performance
- Encourage renewal of sprayers to better performing & canopy matching systems
- Provide growers with a tool to help with system setup
- Provide a tool for French authorities to monitor sprayers
- Totally up to the manufacturer to take part

Consumer protection

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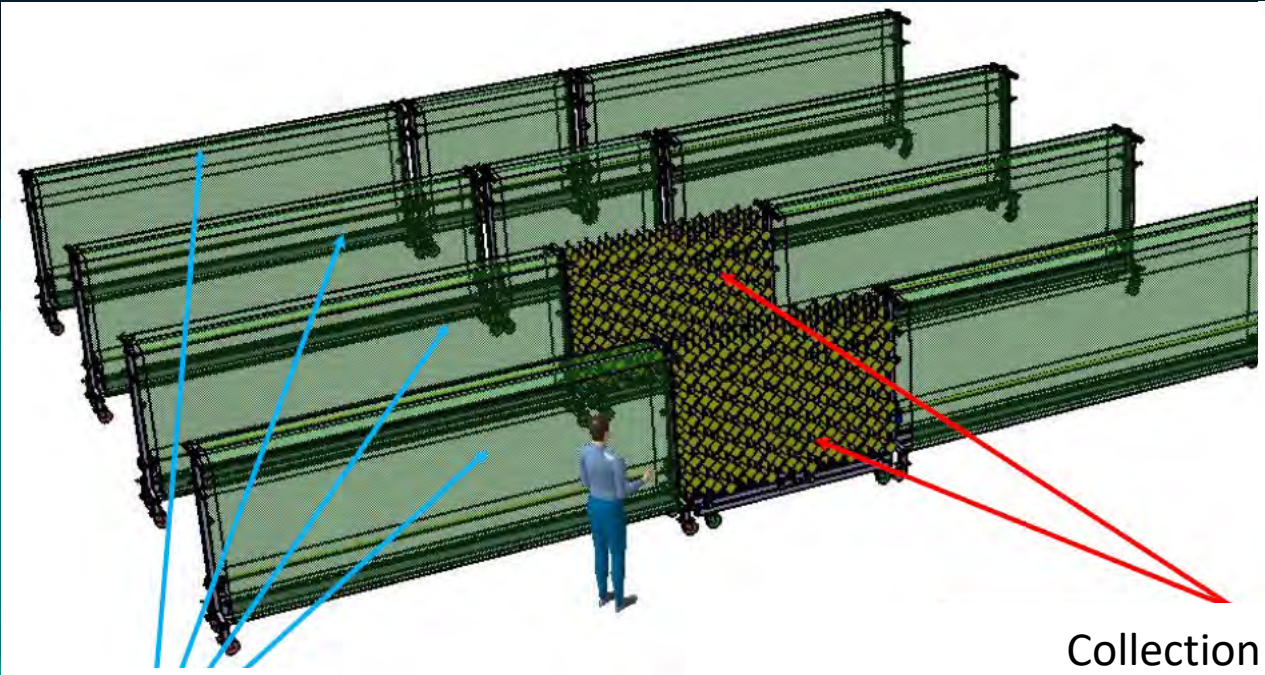
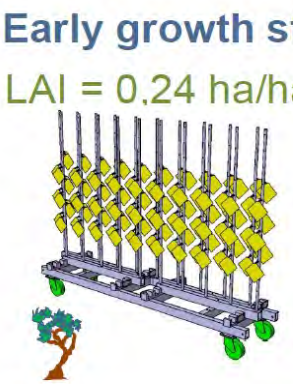
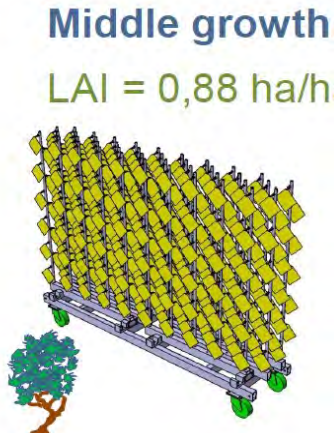
Advancements that can assist in CAS
EvaSray VITI & Orchard test bed

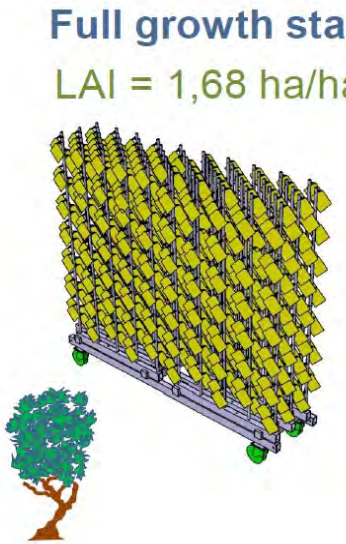


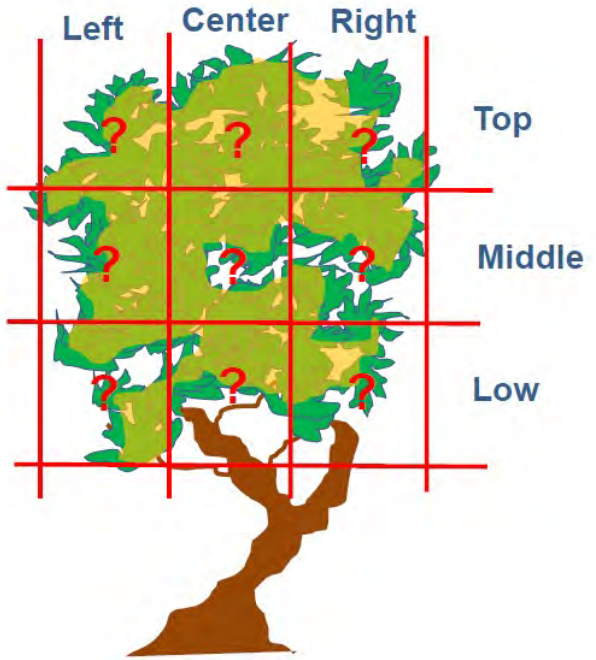
Hedge rows

Collection sections









Advancements that can assist in CAS EvaSray VITI & Orchard test bed

Detailed performance ratings & synthetic notation

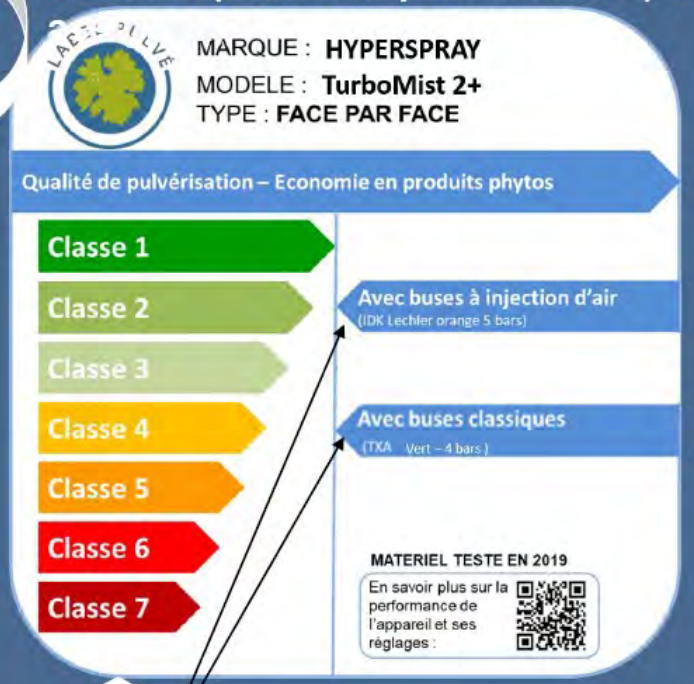
For each growth stage, a detailed performance rating is given

Rating Early growth stage	Rating Middle growth stage	Rating Full growth stage
A+	A	A

Detailed performance rating	Significance of the notation
A+	Reference deposit level maintained with **50%** dose reduction
A	Reference deposit level maintained with **30%** dose reduction
B	Reference deposit level maintained **at full dose rate**
C	Reference deposit level **not reached.**

Triplet of detailed performance ratings	Synthetic notation
(A+A+A)	Classe 1
(A+AA) ou (AA+A)	Classe 2
(A,A,A) ou (A+,A+,B)	Classe 3
(A+,A, B), (A,A+,B) ou (A,A,B)	Classe 4
En dehors de ces exceptions, si la note mini du triplet est B	Classe 5
S'il y a un C dans le triplet	Classe 6
Si il y a au moins 2 C	Classe 7

With the triplet of detailed performance ratings, a synthetic notation (classe of performance) is



A synthetic notation is assigned for each reference setting

Advancements that can assist in CAS

Classified sprayers

performancepulve.fr/materiels/liste

KeyPhase Link | v4.0... | RIMpro home page | Home | National Hu... | Market Access - Hor... | Sage 300 People | EU Pesticides Datab... | Integrated Pest and... | All Bookmarks

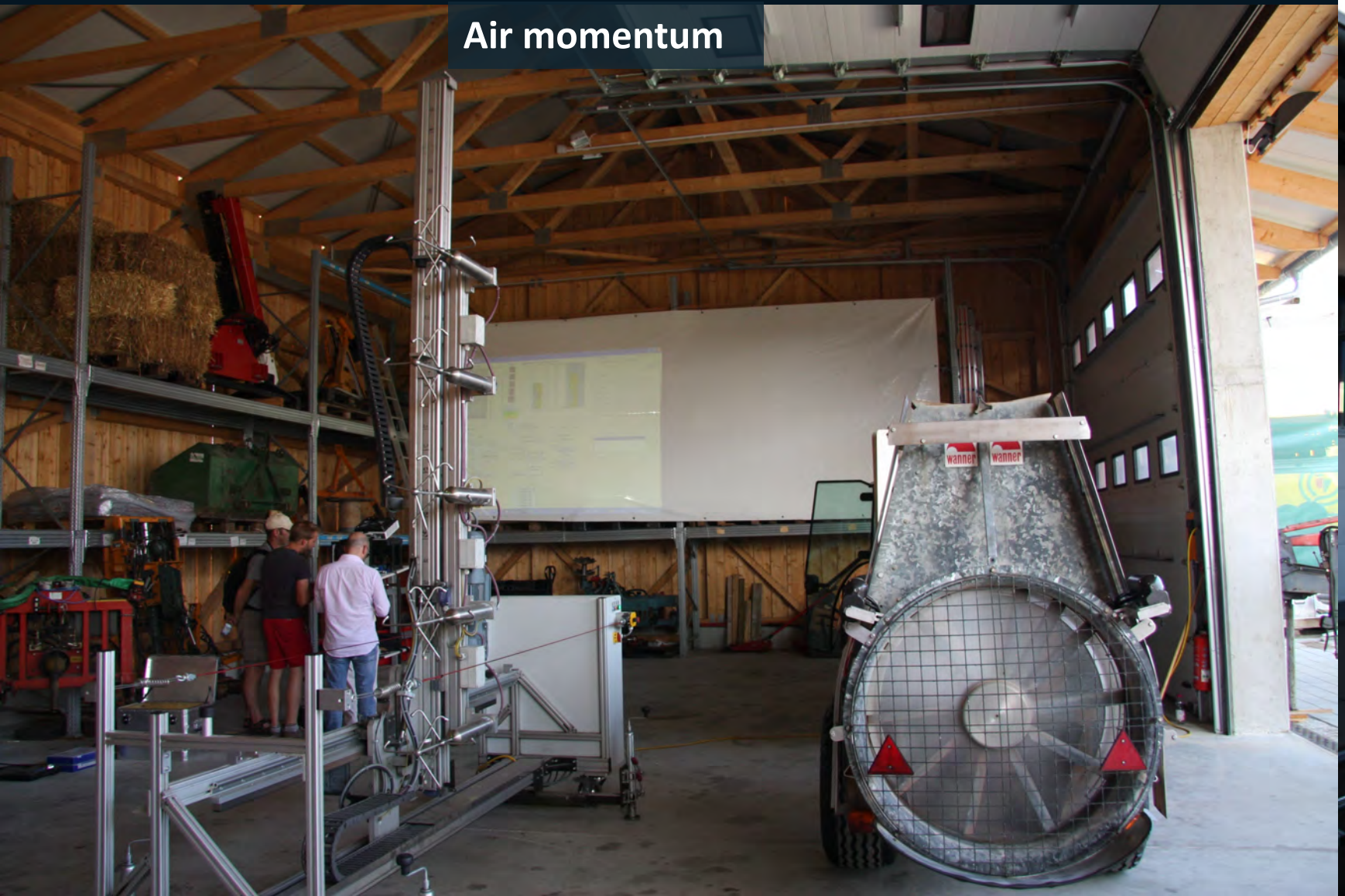
Number of elements: 50

Add to my comparison	Brand	Model	Pictures	Variations	Kind	Technology	Official Drift Reduction Class	PULVÉ® PERFORMANCE Class	View detailed performance
☐	BERTHOUD	Cruis'air / Compact Air Drive (wide vines) Supair ventilation			Face by face with descents	Airborne jet	66% reduction in drift		
☐	BERTHOUD	Win'air Air Drive Ventilation Supair			Face by face with descents	Airborne jet	66% reduction in drift		
☐	CALVET	ECO+ Face by Face 6 descents			Face by face with descents	Mixed (jet and pneumatic)	66% reduction in drift		
☐	CALVET	ECO+ Face by Face 4 descents			Face by face with descents	Mixed (jet and pneumatic)	66% reduction in drift		
☐	DAGNAUD	TURBIPANO			Recovery panels	Airborne jet	90% reduction in drift		
☐	DHUGUES	KOLEOS ST 1250L, 2.1m panels			Recovery panels	Airborne jet	90% reduction in drift		
☐	FRIULI SPRAYERS	DRIFT RECOVERY VVER 600			Recovery panels	Airborne jet	90% reduction in drift		
☐	FRIULI SPRAYERS	DRIFT RECOVERY 2000 & 3000 - Axial turbines			Recovery panels	Airborne jet	90% reduction in drift	1 4	
☐	FRIULI SPRAYERS	DRIFT RECOVERY VVEL 600 & 1000 & 1500			Recovery panels	Airborne jet	90% reduction in drift	3 4	

Advancements that can assist in CAS

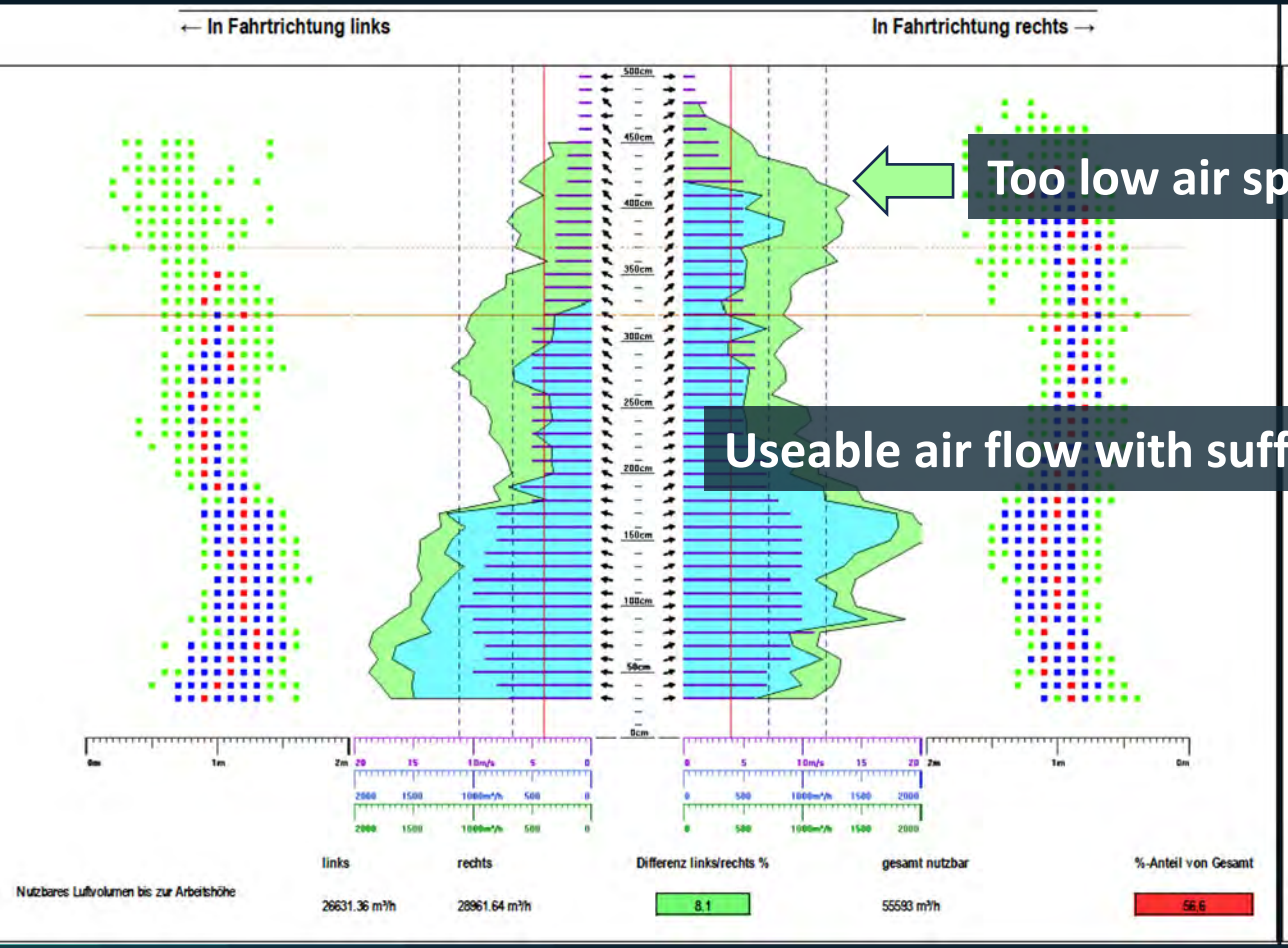
MABO Test bench

Air momentum



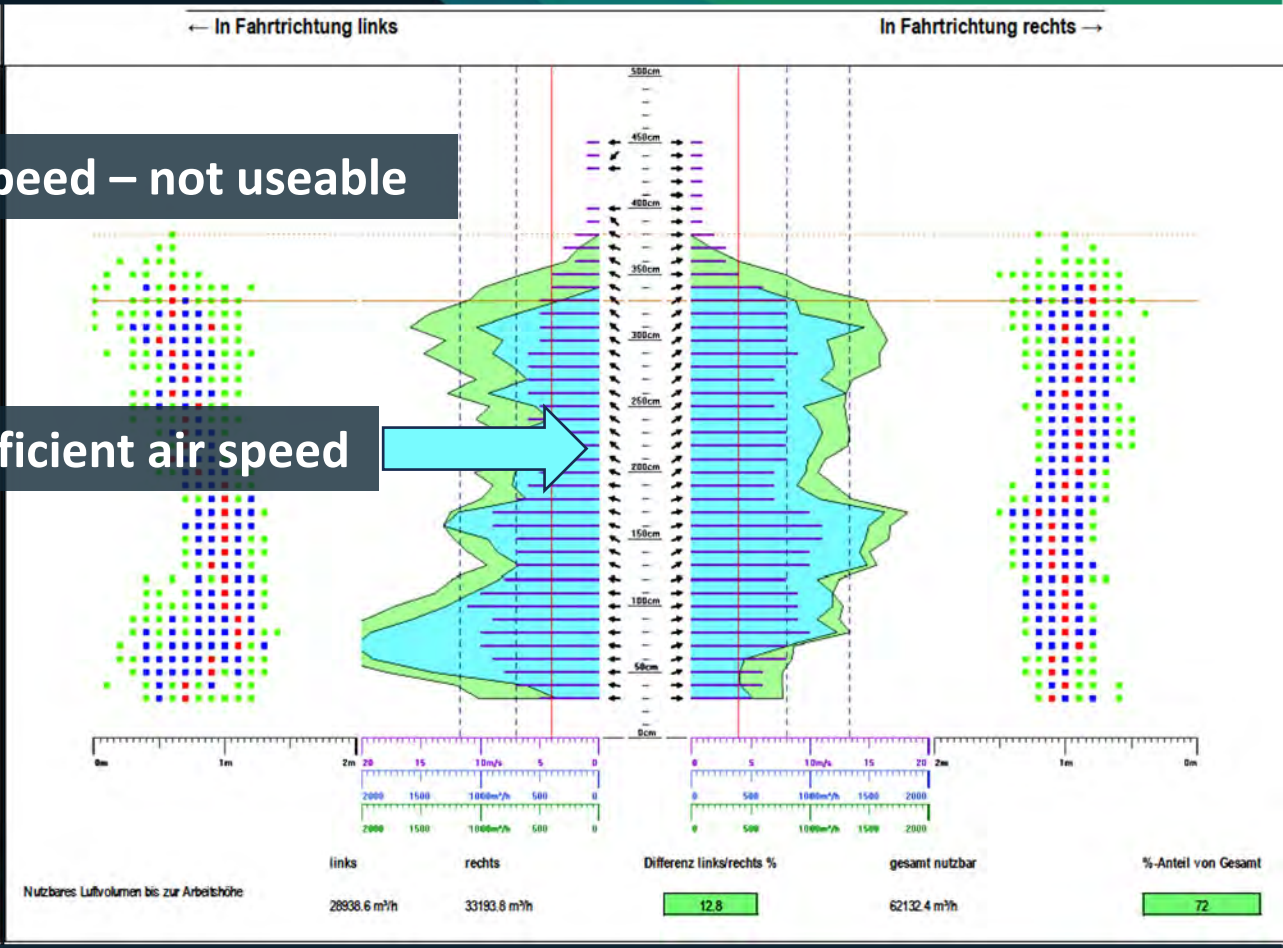
Spray volume distribution

Advancements that can assist in CAS



Too low air speed – not useable

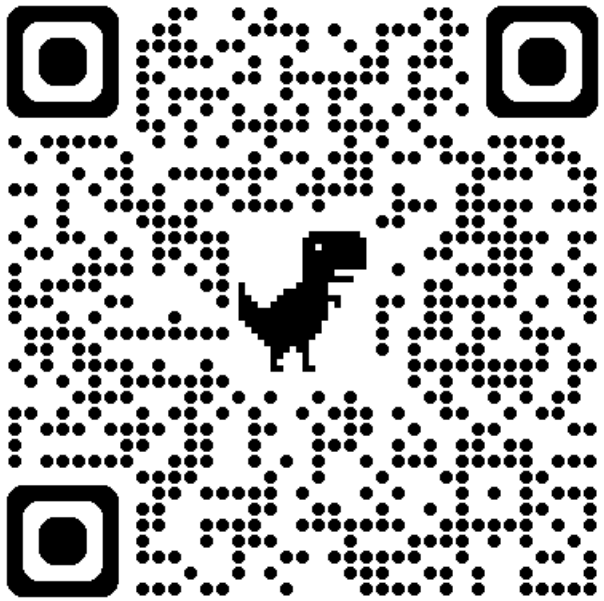
Useable air flow with sufficient air speed



Axial fan sprayer directly from the manufacturer

Same fan adjusted to best possible settings

Advancements that can assist in CAS



AirCheck®
Optimierung Luftverteilung
www.aircheck.eu

The AirCheck™-White List 2023

Fan Types for Highly Efficient and Resource Friendly Crop Protection in 3D-Crops

Fan Type	Maximum working height at 3,0 m row distance m	Maximum angle of the air flow Degree	Usable air flow $m^3_{eff}\ h^{-1}$	Usable air flow per metre maximum working height $m^3_{eff}\ h^{-1}\ m^{-1}$	Power consumption at PTO kW	Diesel consumption at fuel tank $l\ h^{-1}$	CO_2-emissions $kg\ h^{-1}$	Energy efficiency Diesel consumption per m² usable air flow per hour $ml\ m^{-3}_{eff}\ h^{-1}$	Noise emission dB (A)	Drift reduction classification (JKI)* %	AirCheck®-air distribution quality: Classification
Zupan DT-V	2,4	26	45.120	18.800	7,70	2,59	6,87	0,057	84	75	Air Distribution
Weber QU15 H	2,5	-1	31.181	12.472	5,35	1,80	4,77	0,058	79	90 / 75*	Low Loss Spray Application
Lochmann 80UQW 2	2,6	17	51.013	19.620	10,96	3,69	9,78	0,072	84	75	Air Distribution
Weber QU16 H	2,8	5	38.256	13.663	7,73	2,60	6,90	0,068	78	90	Low Loss Spray Application
Wanner ZA28	2,8	39	41.341	14.765	3,12	1,05	2,78	0,025	83	90	Low Loss Spray Application
Lochmann 80UQ2-A	3,3	-2	50.320	15.248	12,70	4,28	11,33	0,085	87	75 / 95 (AFC) / 75**	Air Distribution
Weber QU17 H	3,3	5	43.376	13.144	7,73	2,60	6,90	0,060	79	50	Low Loss Spray Application
Weber QU15,5-12 H	3,3	21	47.011	14.246	9,26	3,12	8,26	0,066	78	75	Low Loss Spray Application
Zupan DT CR-O	3,4	43	53.009	15.591	19,20	6,46	17,13	0,122	87	75	Air Distribution
Wanner H63	3,5	15	41.221	11.777	7,01	2,36	6,26	0,057	83	95	Low Loss Spray Application
Lochmann 90UQH2-A	3,5	41	68.904	19.687	16,70	5,62	14,90	0,082	90	95 / 75**	Low Loss Spray Application
Waibl Q / 09	3,5	45	61.482	17.566	11,00	3,70	9,81	0,060	87	75	Air Distribution
Wanner ZA32	3,5	49	59.197	16.913	8,56	2,88	7,64	0,049	84	90 / 75*	Low Loss Spray Application
Zupan DT MAXI-O	3,6	49	72.737	20.205	18,10	6,09	16,15	0,084	85	75	Air Distribution
Zupan DT-O	3,7	49	56.205	15.191	8,70	2,93	2,33	0,052	80	95 (LMR) / 75**	Low Loss Spray Application
Wanner 36GA nA	3,7	52	74.800	20.216	11,75	3,96	10,48	0,053	84	90	Low Loss Spray Application
Lochmann 80UQ 2	3,8	50	60.820	16.005	11,10	3,74	9,90	0,061	85	75	Air Distribution
Lochmann 90Q 2	3,9	55	69.774	17.891	17,30	5,82	15,44	0,083	86	90	Low Loss Spray Application
Lochmann 90UQ 2	3,9	56	81.449	20.884	17,30	5,82	15,44	0,072	86	75	Air Distribution
Wanner 36GA mhA	4,0	53	69.455	17.364	11,75	3,96	10,48	0,057	84	75	Air Distribution
Wanner 42GA	4,0	55	107.871	26.968	16,65	5,61	14,86	0,052	89	95	Low Loss Spray Application
Lochmann 90QB 2	4,0	59	75.184	18.796	19,60	6,60	17,49	0,088	87	75	Air Distribution
Lochmann 90UQH 2	4,1	53	74.521	18.176	16,40	5,52	14,63	0,074	87	75	Air Distribution

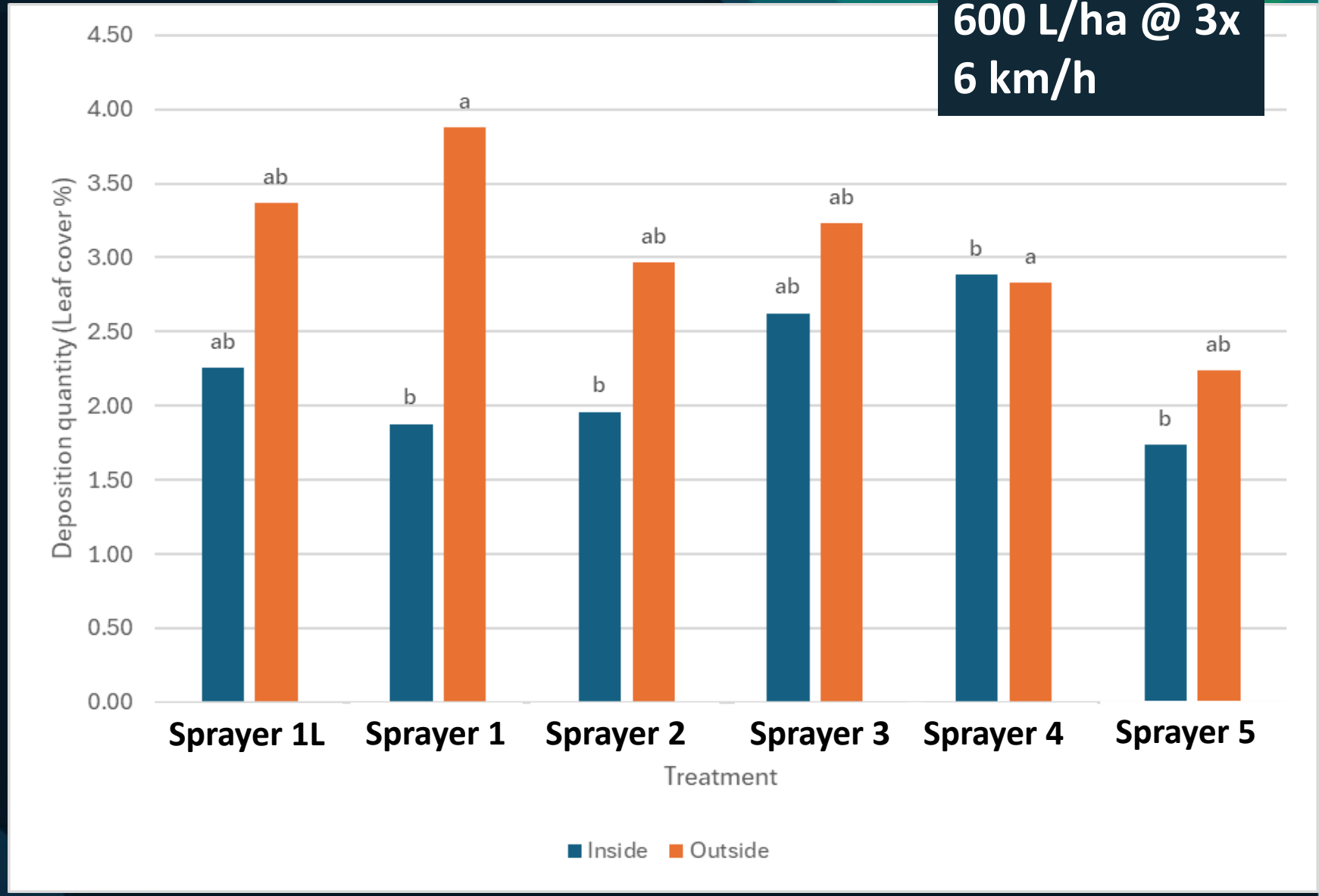
Please note that the listing of a fan type in the **AirCheck®**-white list only confirms the basic suitability of this fan **type** for target adapted spray application. This does not automatically apply to any individual fan from the series due to unavoidable deviations of production and assembly of air ducting components and the necessity to adjust the air distribution for canopy adapted spray application to the requirements of the buyer through an individual adjustment and verification. This suitability is only confirmed by the positive air distribution protocol of the individual fan according the actual **AirCheck®**-guidelines, the entering of the individual number of an **AirCheck®**-test badge in this protocol, and the affixing of this test badge on the

Advancements that can assist in CAS
Local evaluations

TRV 1874 L/ha
600 L/ha @ 3x
6 km/h

Pros…
- Very accurate

Challenges:
- Expensive
- Laborious (can take up to a month!)
- Manufactures usually not very keen on sharing the data



Sprayer speed (CAS)

Critical factor to ensure accurate spray application

Speed depends on:

- **Sprayer air volume output (m^3/h)**

Allowable spray speed (km/h) = Available air volume (m^3/h)/ 1000 × tree height (m) × width (m)

- **Condition and slope of orchard floor**
- **Row spacing**
- **Logistics (number of sprayers available *vs* effective spraying time)**
- **Canopy volume, complexity and density**

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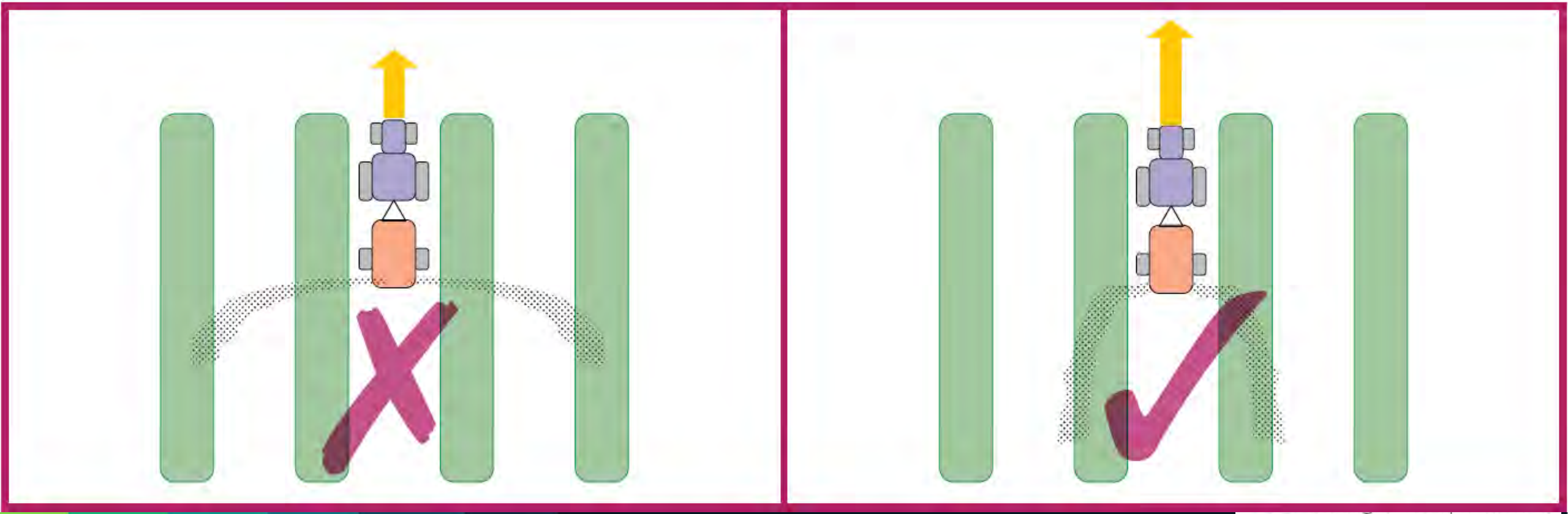
Sprayer speed (CAS)

- High profile sprayerwith theoretical air volume of 36 200 m3/h (low fan @ 540 rpm)
  - 5.95 km/h
  - Realistic in scenario?
- Low profile axial fan theoretical air volume of 48 200 m3/h (low fan @ 540 rpm)
  - 7.92 km/h
  - Realistic in scenario?

Sprayer speed (CAS)

Matching sprayer speed to canopy – evaluate visually

- Start at 540 rpm, high fan selection > if excessive, move to low fan selection…
- Keep below calculated allowable ground speed



Sprayer air volume (CAS)

Matching sprayer air volume to canopy

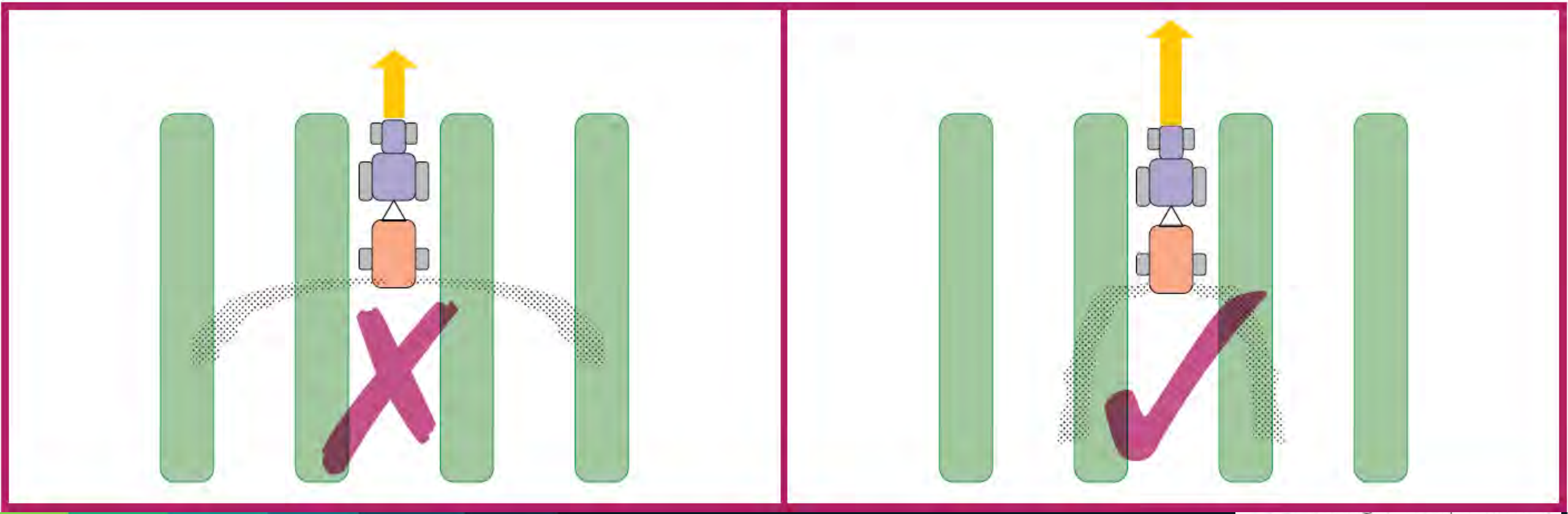
- If speed is not enough to bend air column into canopy
- Gear selection: Low and high gear
- Blade pitch
  - Narrow angles less air (28.5 ˚)
  - Wider angles more air (38.5 ˚)
- Blade diameter
  - Larger diameter = higher air volumes
- PTO manipulation
  - Slower PTO revolutions = less air
  - Has impact on delivery and mixing capability of pump (L/min)

Comet APS 145 diafragmapomp @ 20 bar	
r.p.m.	ℓ/min
400	109
450	122
500	135
550	145

Sprayer air volume (CAS)

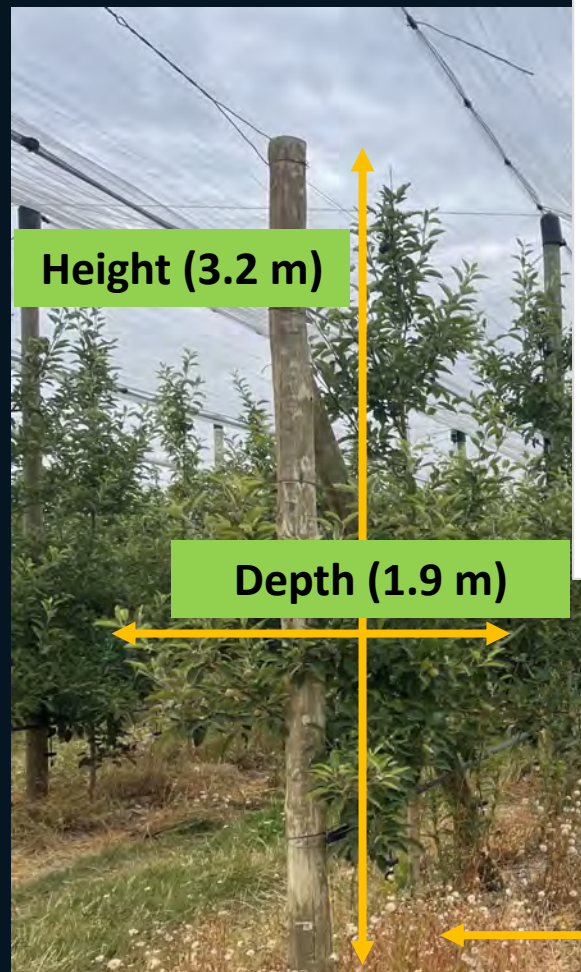
Matching sprayer air volume to canopy – evaluate visually

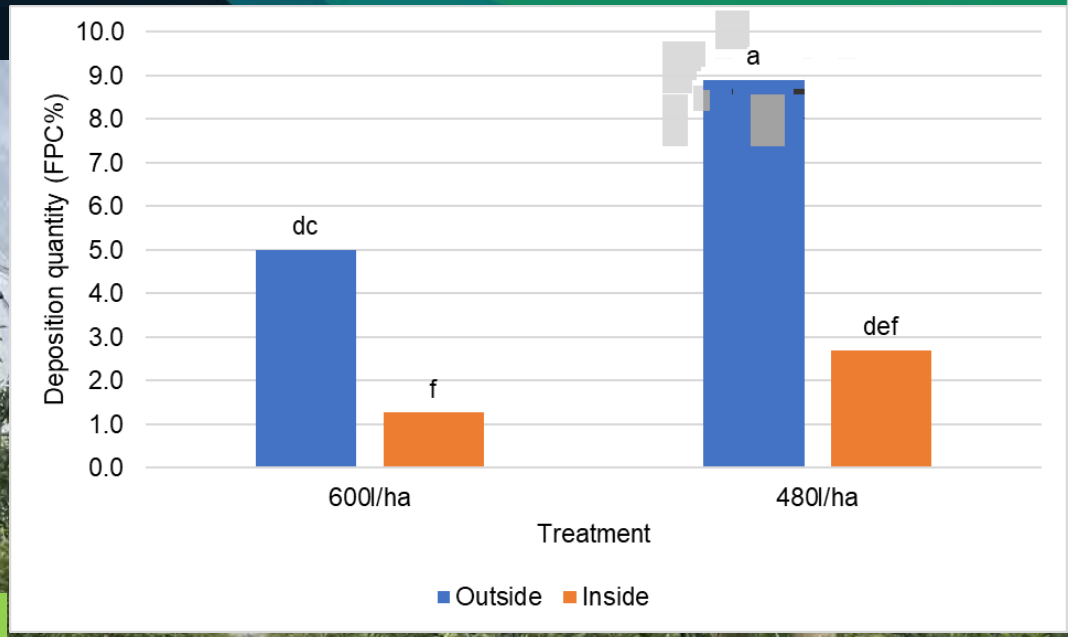
- **Especially top of trees!**
- **Low profile and high profile sprayers with top airflow angle > 40˚**

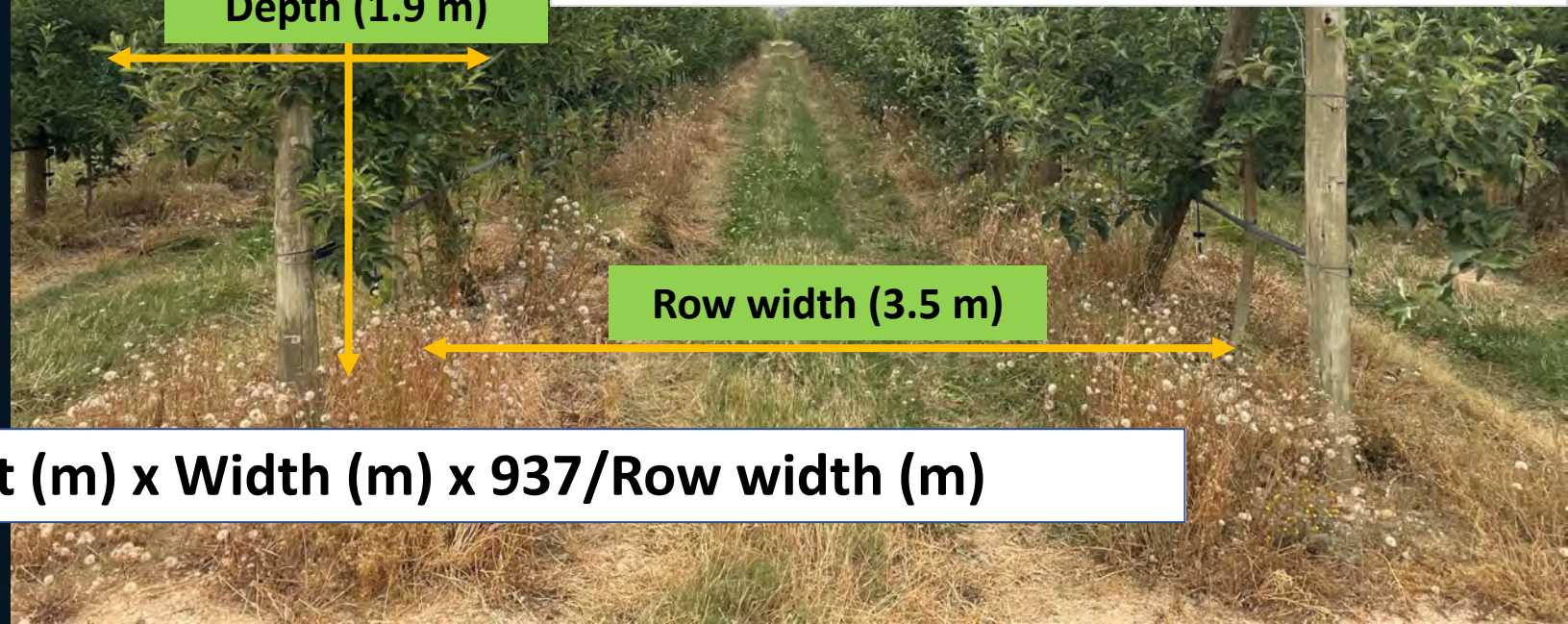


Spray volume (CAS)

- The 3 to 4x concetration guideline is used when deciding on water volume choice for high density orchards...
- TRV = 1628 L/ha
- Recommended water volume 450-600 L/ha
- 3-4x concentration at 100% of HVR.





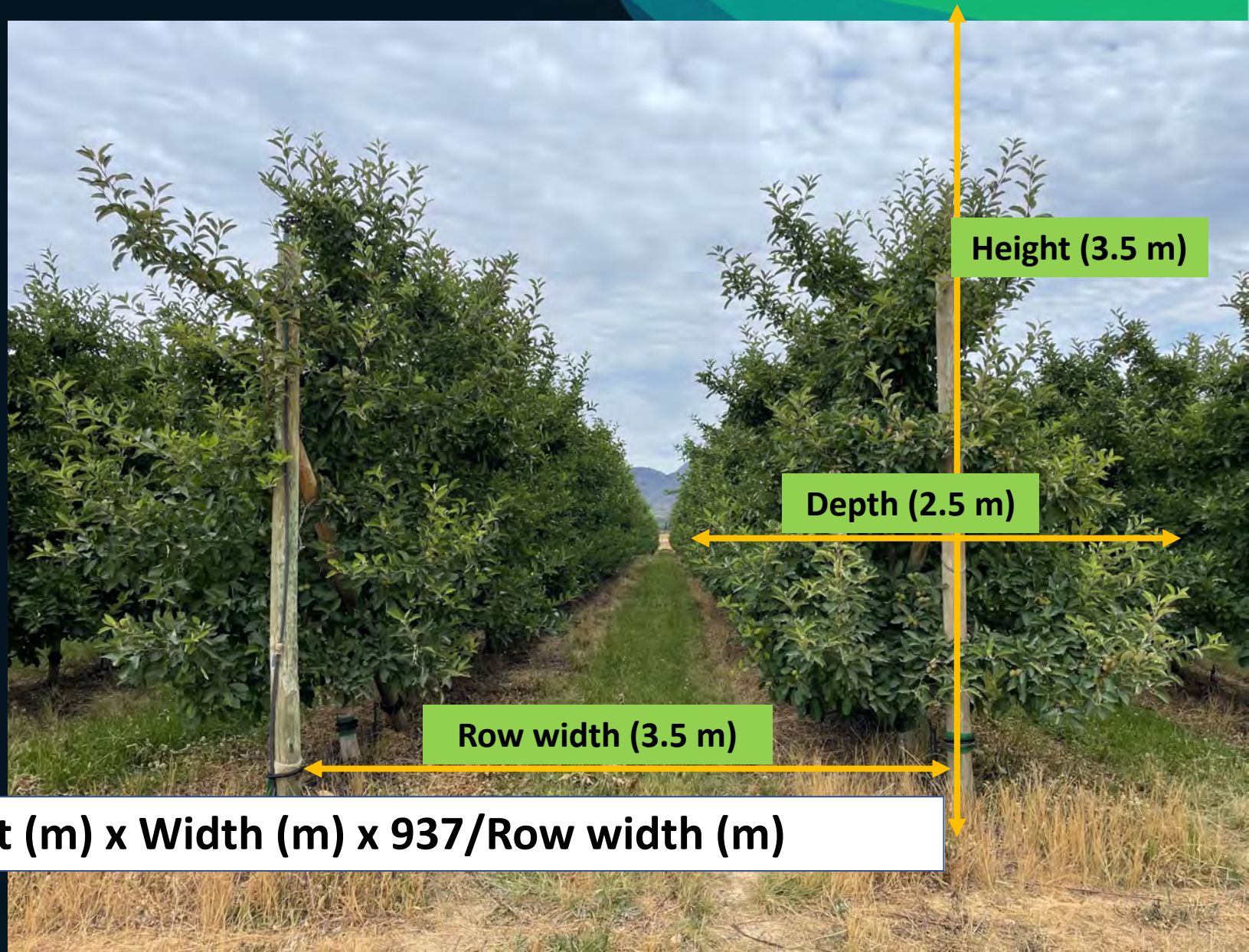


TRV = Height (m) x Width (m) x 937/Row width (m)

Spray volume (CAS)

- TRV = 2343 L/ha
- 650 to 750 L/ha
- 3-4x concentration at 100% of HVR.

- There can be high variation between orchards in relation to water volume choice.
- Measure TRV regularly and adapt as necessary.

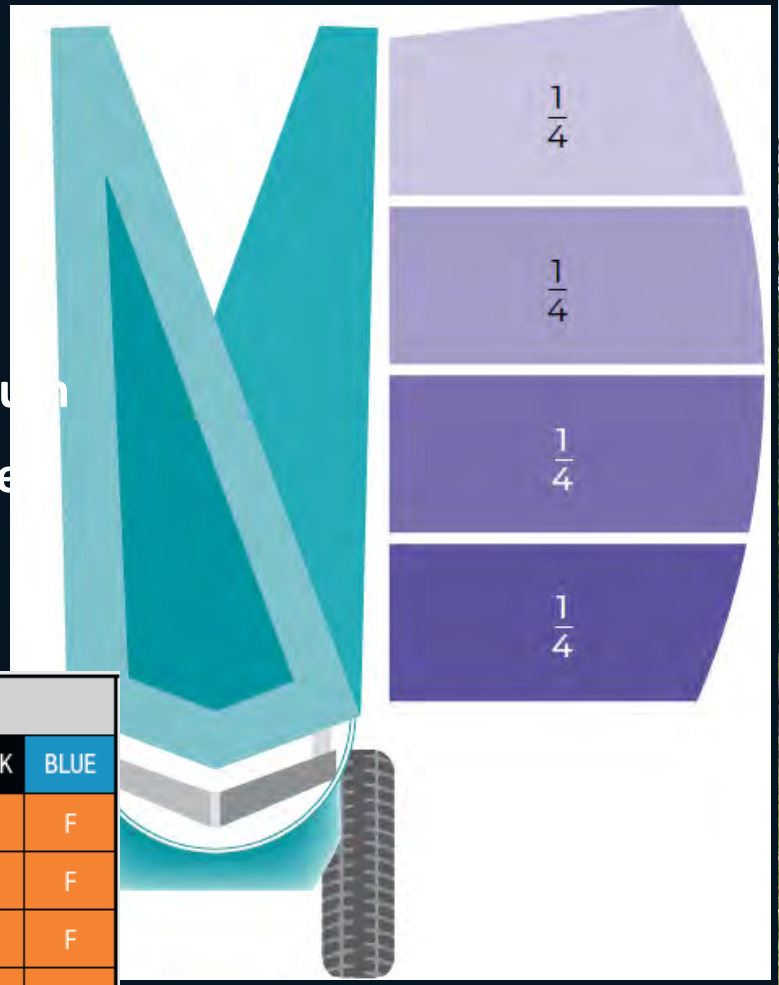


TRV = Height (m) x Width (m) x 937/Row width (m)

Spray volume (CAS)

$$L/\min \, per \; nozzle = \frac{\text{Speed (k m/h)} \times \text{Row spacing (m)} \times \text{Spray volume (L/h a)}}{\text{Factor (600)} \times \text{No. open nozzles}}$$

- Same nozzle top to bottom
- Use hollow cone systems from reputable manufactures
- For example Albuz ATR
- Use fine to very fine droplet spectru
- Stay in pressure range recommende by manufacturer – **replace when needed**



bar	ATR 80°									
	WHITE	LILAC	BROWN	YELLOW	ORANGE	RED	GREY	GREEN	BLACK	BLUE
5	VF	VF	VF	VF	VF	F	F	F	F	F
7	VF	VF	VF	VF	VF	F	F	F	F	F
10	VF	VF	VF	VF	VF	F	F	F	F	F
15	VF	VF	VF	VF	VF	VF	F	F	F	F
20	VF	VF	VF	VF	VF	VF	VF	VF	VF	VF

What advancements are applicable to our scenario?

$450 000 MiniGuss + SmartApply acquired but not set up correctly?

What are you gaining?

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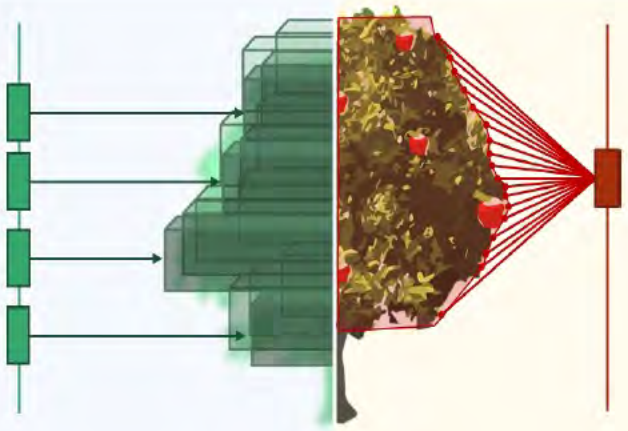
Advancements that can assist in CAS
Canopy volume/density sensing technology

Ultrasonic sensor, Laser scanner (LIDAR)

- **Detecting and measuring the distance to the target canopy**

- **Measure canopy position and canopy contour at different heights and determine canopy volume and gaps between trees**

Ultrasonic
Limited resolution
(One point)
Low price and
robustness



LiDAR
High resolution
(Multiple points)
High price

Advancements that can assist in CAS Precision application

Variable rate application systems (combined with canopy sensing technology)

- Spray pressure adaptation (on-the fly calibration) to manipulate spray volume at varying sprayer speeds
- Individual nozzle selection (on/off switching)/Electrical or Pneumatic selection of multiple nozzles

Advancements that can assist in CAS
Canopy volume/density sensing technology

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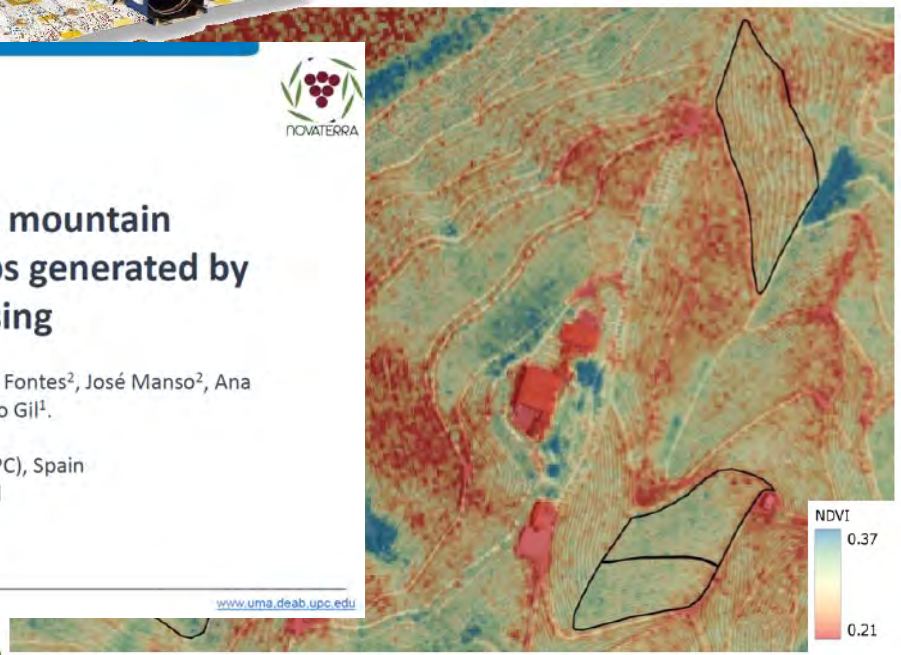
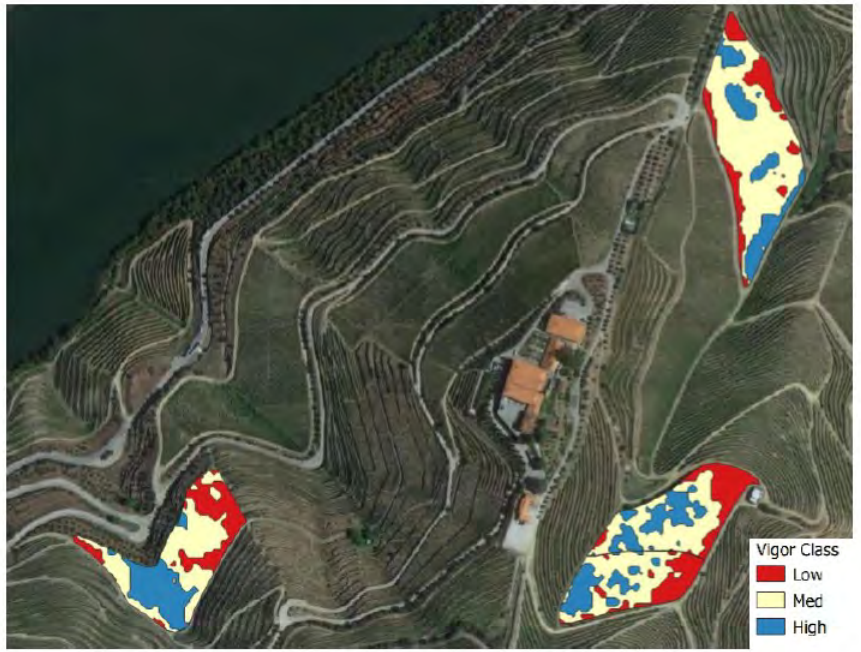
Methodology

Relative Classification based on 7th quartile approach + 5x5 kernel neighbor filter





Planet Labs, 3 m/pixel, 8 spectral bands and near daily revisit

www.uma.deab.upc.edu

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SOGRAPE

NOVATERRA

Variable Rate Application in mountain viticulture based on canopy maps generated by satellite remote sensing

Fran Garcia-Ruiz[1], Antonio Graça[2], Sofía Correia[2], Natacha Fontes[2], José Manso[2], Ana Rita Ferreira[2], Ramón Salcedo[1], Emilio Gil[1].

[1]Universitat Politècnica de Catalunya (UPC), Spain
[2]SOGRAPE Vinhos S.A., Portugal

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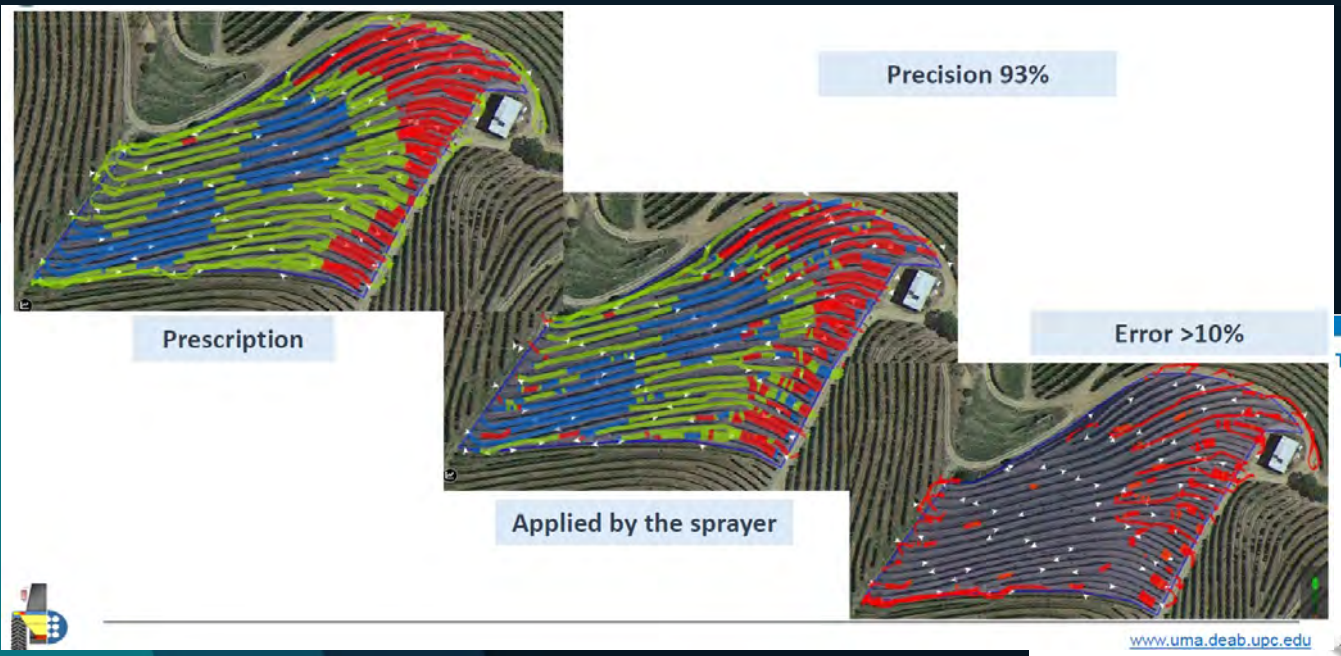
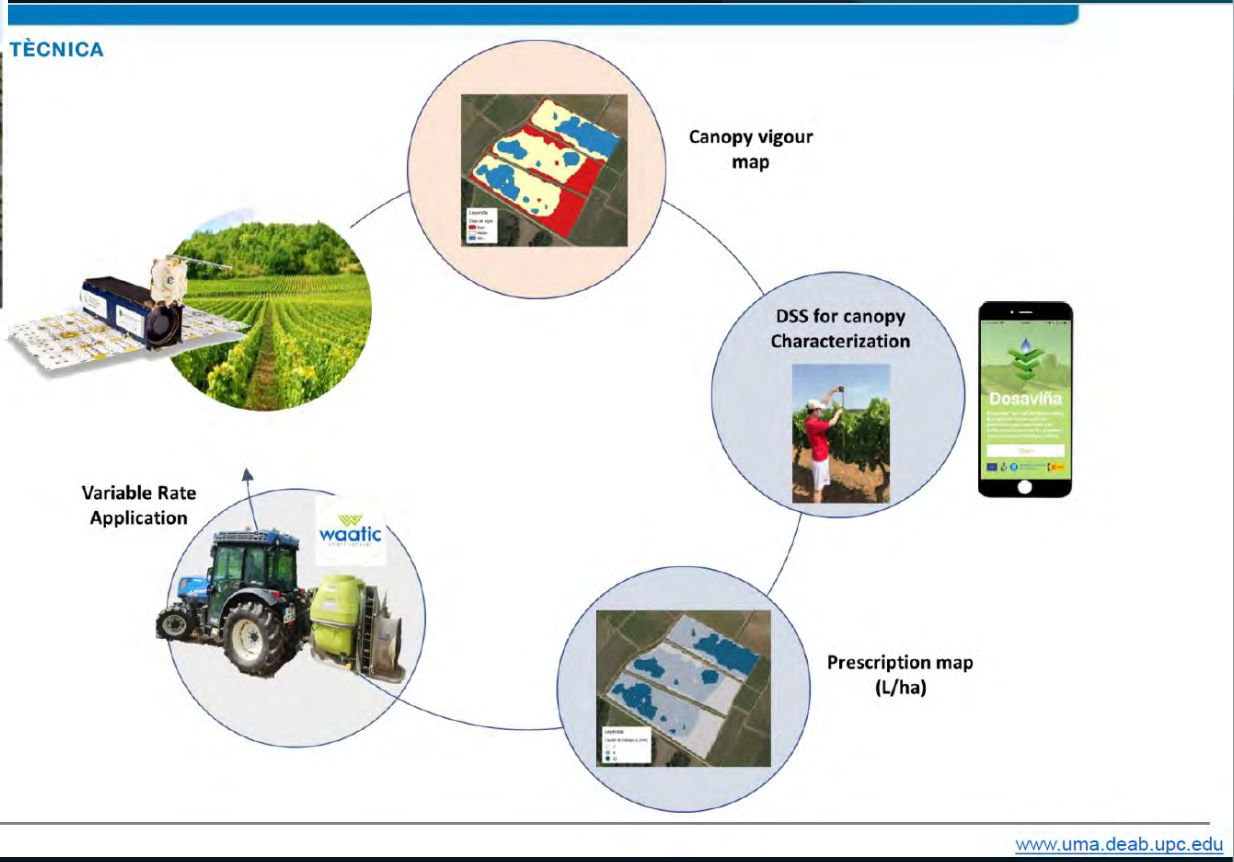
Advancements that can assist in CAS
Individual nozzle selection



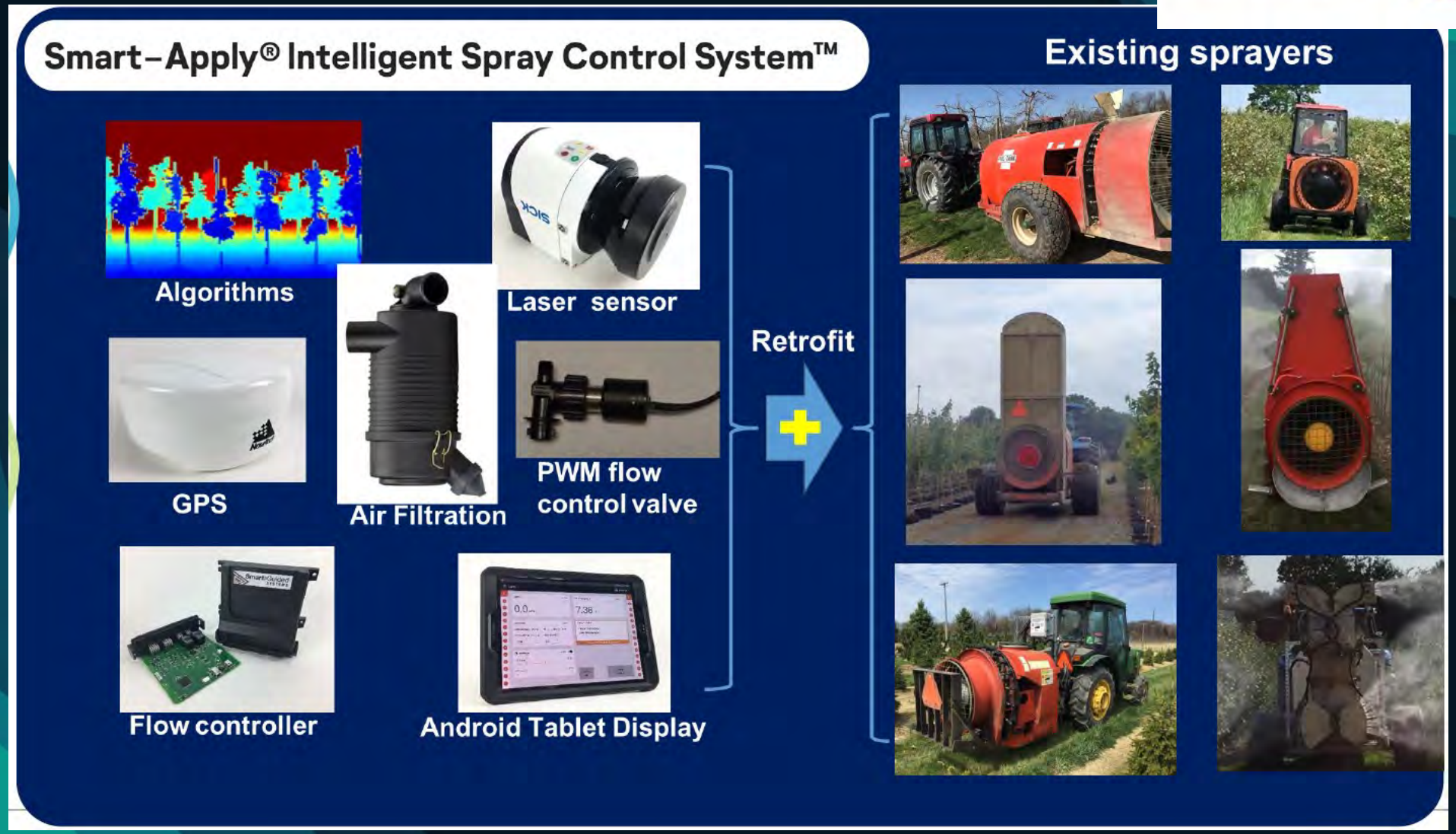
- 3 nozzles per nozzle position – nozzle selected by the created precision map
- Spray volume reduction per ha up to 33% from constant rate
- What would the influence be of green inner rows and weed control throughout the season?



Advancements that can assist in CAS

Smart Apply

Smart Apply®



Advancements that can assist in CAS
Precision application

Variable rate application systems (combined with canopy sensing technology)

- For example, a BRAVO 180
- Allows for variable speed spraying
- Auto calibration keeping spray volume per ha constant

- Cons: Limited by nozzle selection & specific pressure use spectrum of selected nozzle
- Can only be used on systems with correct air volume/speed = momentum based on canopy volume

Canopy Adapted Spraying (CAS) – the Benefits

- Increases work rate
  - Optimal water volume, sprayer speed and air volume
- Reduces the risk of operator contamination
- Reduces exo- and endo spray drift
  - Where lower air volumes & correct nozzle layout is used
  - If lower air volume @ lower PTO/RPM selection is used
- Reduces noise emission
- Reduces bystander conflict (nosy neighbours)
- Possibility of reduced fuel consumption, time and input cost.

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