Drone Safety & Regulations in APAC

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Bayer

The world needs more innovation in agriculture

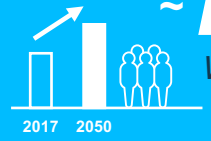
Need to produce

significantly more while protecting natural resources

Demand

50 %
More food, feed & biofuel needed*

~10 Bn
*World population**



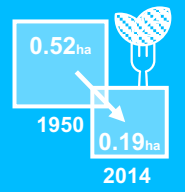
70 %
More meat in developing nations needed*

Supply

17 %
*Harvest loses**

12 Mio
Ha of agricultural land loss annually

0.16 ha
*Land for food per capita***



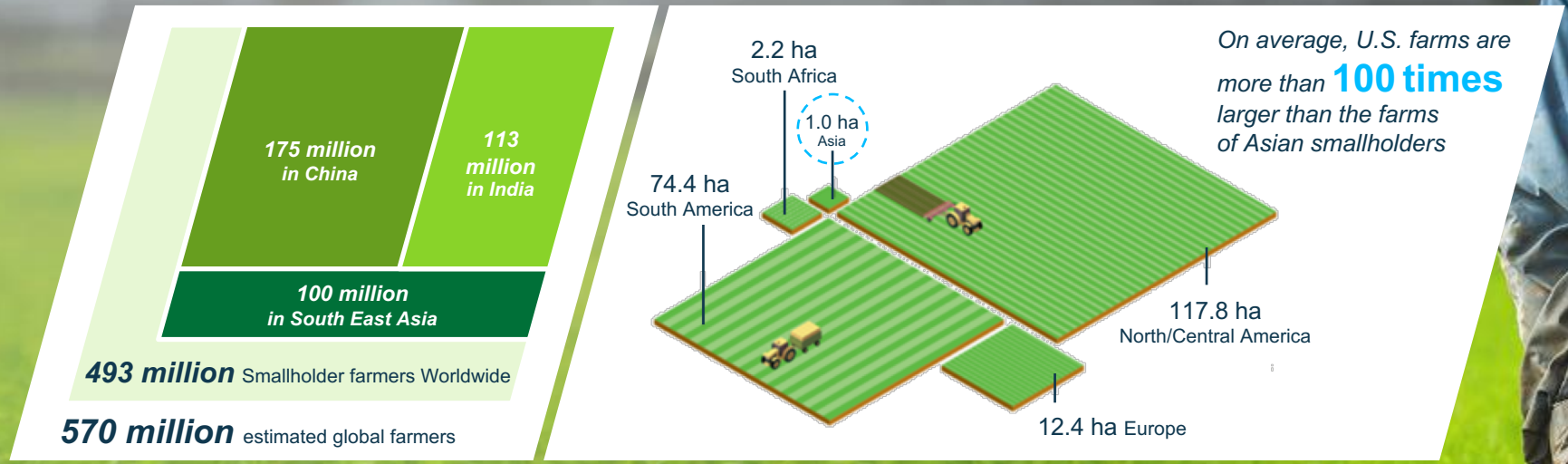
Source: FAO 2017, The Future of Food and Agriculture
* By 2050; ** 2050 land for food per capita estimate: 2000: 0.24ha; 1950: 0.52ha

Smallholders' footprint in Asia Pacific is unmatched globally

Land ownership likely to remain fragmented despite slow consolidation in some countries

Asia Pacific accounts for ~80% of smallholder farmers worldwide

with China, India and South East Asia home around ~388 million



On average, U.S. farms are more than **100 times** *larger than the farms of Asian smallholders*

Significance in Agriculture and Food Supply

- 80% of food production in developing countries; rising GDP driving food & nutrition demand
- Productivity at ~50% of world average
- EUR 17-20B seed & crop protection market (~16% share of global market) Expected to grow to EUR 23-26B by 2023 (~6.5% CAGR – above global average)**

other data reflect internal estimates based on various external sources Sources: Dalberg Global Report 2016, Inflection Point, FAO

A farmer said… “If I don’t spray, my crop will be destroyed by pests”

Hard to Walk

Operator Exposure

Labor Cost Increase

Aging

“It’s very tough to walk in muddy field with heavy spray tank”,
“It takes 12 hours for 1ha”

Drone Application Technology can drastically change the situation.

Benefit of Drone Based Management

Save Application Costs

	Spray field	Spray 10% of field
UAS	$2/ac	$0.25/ac
Spray rig	$8/ac	$8/ac

Changes the ROI calculation

Can move from minimize passes to optimal management

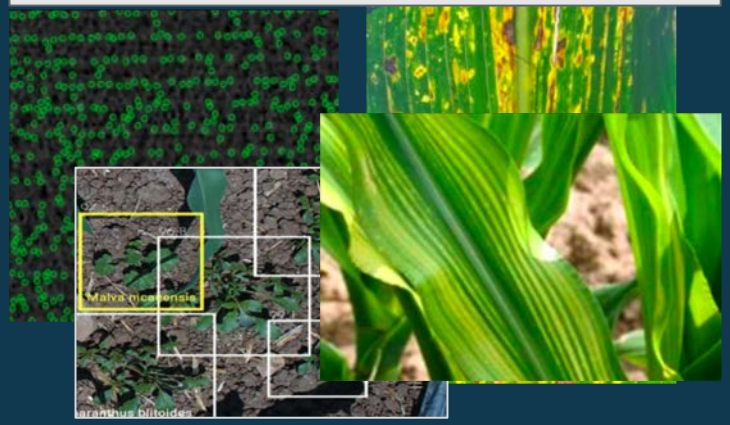
Reduced Crop Damage

Why drive 15 t across a field to apply ounces of product?

- 1-4% yield reductions due to damage from big iron, Compaction penalties in addition

Crop access - crop height, soil moisture, 24 hour

Optimize Management

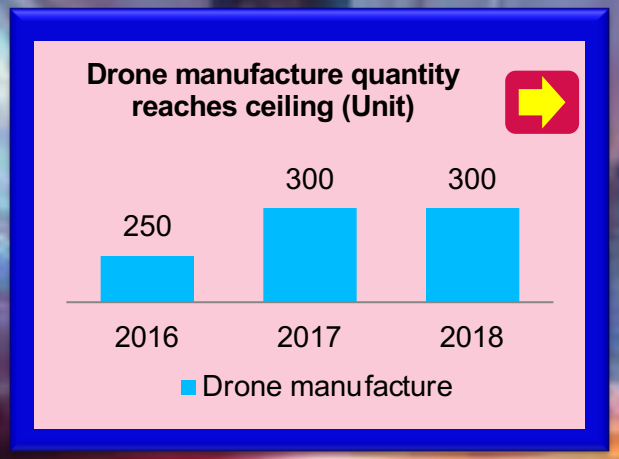


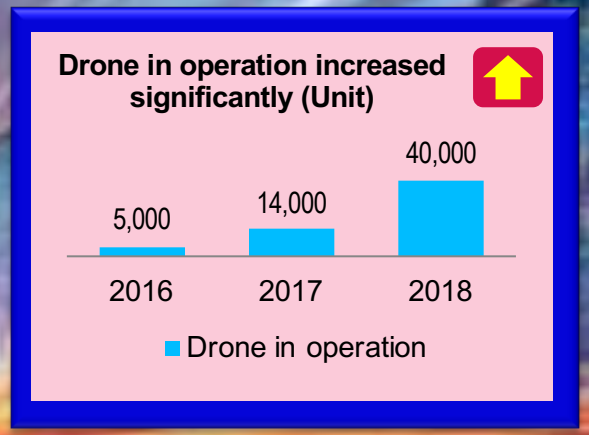
Need based or spot spraying for Pests and Disease

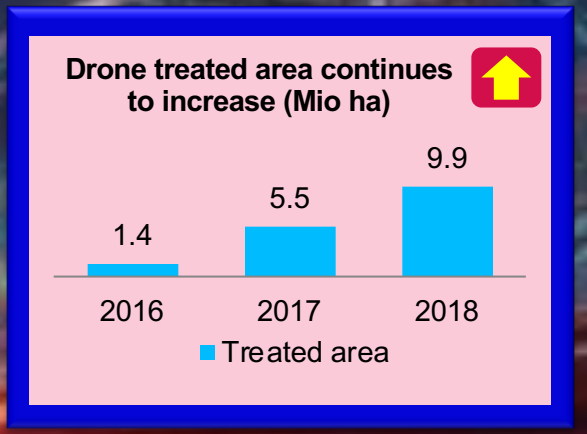
Expansion of niche products such as

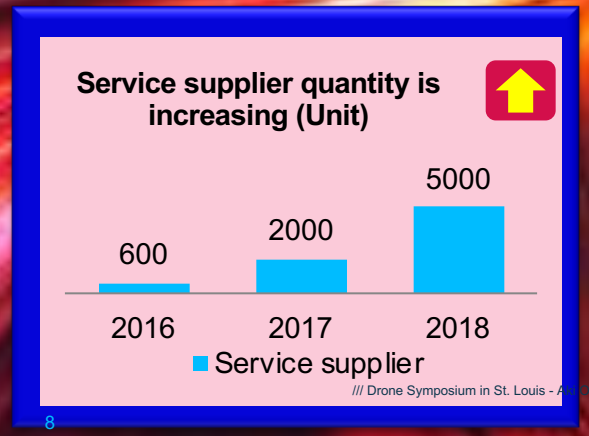
- micronutrients
- plant growth regulators
- Pollination for hybrid production and to increase uniformity
- Cover Crop (small seeded crop) sowing

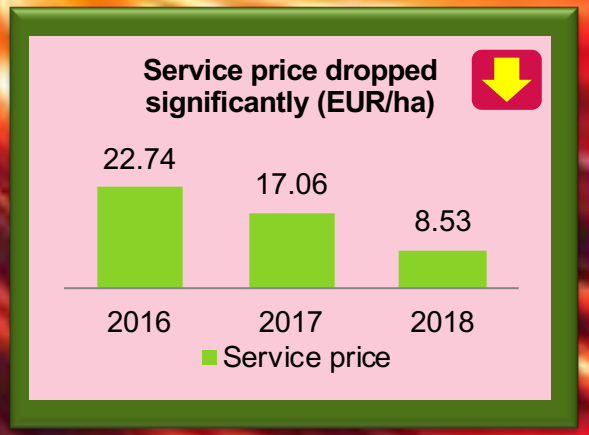
Drone Technology Adoption in China is Very Fast

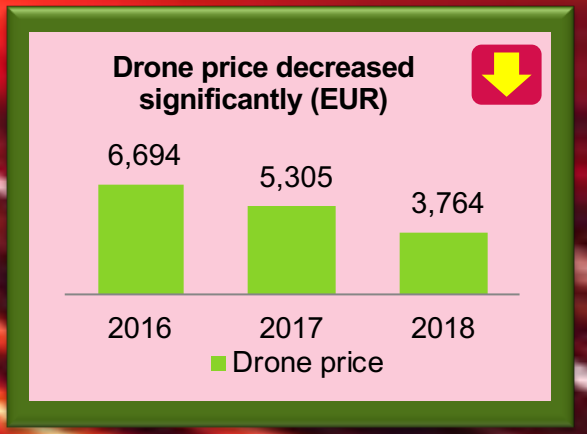












Regulatory

Asia is leading Drone Regulations

Regulatory Consideration on Drone Safety

Regulatory Aspects

Pesticide Application

Safe use SOP

Operator Safety

Operation

Pilot licensing training
Code of conduct

Bio Efficacy

Aviation Law

Crop Residue

Vehicle specifications
Flight restrictions

Off Target Drift
Phyto Risk

Benefits

Application Efficiency
30 times efficient VS manual application

Water Saving
3% water volume of manual application

Cheaper cost
50% treatment cost VS manual application

Safer to operator
Lower pesticide exposure VS manual application

Capturing Benefits of Novel Technology through Safe Use Regulation

Drone Regulations Across Asia

Where can UAS be used for spray applications as of 2019?

- UAS widely used for spray application with registered products

- Well Established UAS Regulation
- 2019 abolish extra UAS data requirement for efficacy & residue trials

- Guidance under Development
Committees formed

Eqator

- Guidance under Development
- Malaysia: implemented
- Philippines: implemented
- Thai: Honor existing registrations; block on vehicle

Drone use and Regulations - Worldwide

ROAD SHOW 2019

Country	Civil Avi.	Operation	Spray	Commercial Application of PPP	Guidelines for Data Generation for Use of Drone in Agriculture
Japan	✓	✓	✓	✓	De-regulation 07/2019 = Role Model No additional residue & efficacy trials
Korea	✓	✓	✓	✓	UAS Registration
Philippines	✓	✓	🔒	⚠	Under Development – Field testing guidelines
Malaysia	✓	✓	✓	✓	Drone label requires efficacy Trials
Thailand	🔒	🔒	🔒	⚠	Proposal: no additional data requirements for registered products
Indonesia	🔒	🔒	🔒	⚠	Proposal: no additional data requirements for registered products
India	🔒	🔒	🔒	⚠	Committee's established following Bayer road show
China	✓	✓	🔒	✓	Commercial use permitted while guidance is developed in parallel

Regulations – **Safe Use SOP**

- ***Drone Safe Use SOP***

- ***Stewardship Video***
- ***Brochure***
- ***Link to Video***

Regulations – Safe Use SOP for Human & Environmental Safety

Why drone application of Crop protection products

- High operational efficiency (20–30 times faster than Backpack··· can spray 10 hac in 1 hour)
- Less operator exposure (no direct contact)
- Safe to crops (Do not damage crop as fly above crop)
- Easy to use in all terrains (where manual spray is tough)
- Cost effective (Less labor intensive)

Key stewardship measures for excellent performance and safety

Flying height	Flying speed	Spray width	Water volume	Anti-drift nozzle	Adjuvant	Compatibility (if tank mix)
1.5–2.5m above crop	4–6m/s	3–5m (depend on nozzle and position)	10–15 L/hac	100–150 μ m Droplet size	again evaporation and drift (Methylation vegetable oil)	no visible flocculation, foam , Phase separation

Bayer drone operation and stewardship guideline (SOP)

Pre application:

1.Confirm not fly in the drone-forbidden area (airport or electronic station).
2.Understand the law and regulations where they operate.
3.Ensure the operators was trained on both drone operation and safe use pesticide Use adjuvant again evaporation and drift ability (Methylation vegetable oil).

Check the drone before application

4.No drinks within 8 hours preceding operation.
5.Check drone in good condition, no leak in the spraying system.
6.Confirm place for takeoff and landing, tank mix operations.
7.Check and mark the obstacles (walls, trees) around the field for safe operation.
8.Set up at least 50m buffer zone between drone treatment and the non-target crop.
9.Confirm water sources – Do not spray pesticides near water sources (less than 100m) to avoid polluting water sources.

10.Check compatibility if tank mixing two products (no visible flocculation, foam , Phase separation).

During application

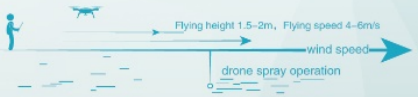
1.Read labels carefully to understand safety guidance.
2.Wear Personal Protect Equipment (PPE) (what···.)
3.Do not eat, drink or smoke while spraying.

4.Properly calibrate the nozzle flow, and ensure accurate dosage.
5.Confirm the flying route was reasonable to minimize turn around.
6.Operation team shall always stay at the downwind end of the field and backlight direction.

7.To spray with pure water first to test operation for at least 5 min.

8.Compatibility trials should be conducted before application if need.
9.Two step dilutions to fully dissolve the pesticide.
10.Adopt proper pressure for optimized droplet spectrum (100–150 μ m).
11.Check whether condition: wind speed less than 3m/s, temperature lower than 35 degrees, humidity above 50%).

12.Flying height: 1.5–2.5 m above target crop.
13.Water volume: normally 10–15 L/h.
14.Flying speed: 4–6 m/s.



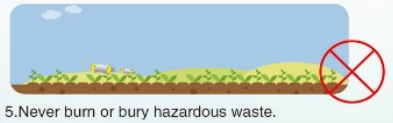
15.Avoid having to walk through crop which has been contaminated by drifting spray.
16.Avoid spraying during honeybee activity or honey collecting. Avoid spray drift to flowering nectar crop.

17.When spraying pesticides that are toxic to non-target organisms such as fish, birds and silkworm, strictly abide by the product label requirements and take effective measures to avoid risks.

18.Use anti-drift nozzle to decrease drift to human and environment (Air–mix, 110 01, 110 075).

Post application

1.Timely evacuation and transfer to fresh air.
2.Triple rinse of empty container is mandatory.
3.Ensure waste generated is kept to a minimum.
4.The disposal of waste must conform to the local laws. Residual liquid or waste liquid should be diluted further and sprayed onto the discard area or recycled.



5.Never burn or bury hazardous waste.
6.Never leave empty containers in the field. Send triple rinsed empty containers to the nearest approved collection site.
7.Set up warning signs in the spray area for remind people
8.Take a shower and put on clean clothes.
9.To prevent leakage of plant protection products in the process of transport and waiting to use.
10.Securely stored away from unauthorized people, animals and food when transporting and storing PPP. Safely dispose all spills immediately.

UAS Safety & Efficacy

Field Trials: Efficacy, Operator, Dietary, Environment

Human & Environmental Safety of UAS Applications

	Regulatory Concern	Product Safety Trial
	**Bio-Efficacy** Are efficacy levels as good as with conventional spraying ?	20 Products in 38 bio-efficacy trials in Thailand, China, Philippines, Malaysia, Indonesia in rice, corn, wheat
	**Operator Safety** Can drone applications improve safety of the operator?	Full Body Dosimeter Tracer Operator Exposure Study with MARDI (Malaysia) benchmarking conventional vs. UAS (OECD (97)148)
	**Dietary Safety** Are crop residues different due to low water volume applications?	Crop residue study in rice in Thailand benchmarking drone vs. conventional
	**Environmental Safety** How can drift be limited to avoid phytotox or undue environmental impact?	Spray Drift Exposure Trial (ISO 22866) and tracer analytics with DoA

Application Methods for UAS – **Insecticides, Fungicides**

➲ **Variety of NOZZLES and FLIGHT MODE**

Different type of nozzles

Different flight modes

Link to YouTube
XAG Orchard Spraying for Citrus Trees
https://www.youtube.com/watch?v=jBdE5I1upuQ

Application Methods for UAS – **Rice Herbicides**

➲ **DRIP** **Application at lower water volume (5 l/ha) than normal spray (8 - 20 - 50 l/ha)**

Yoshitaka

Application Methods for UAS – **Solid**

➲SOLID SPREADING Application including SEEDS

Link to YouTube https://www.youtube.com/watch?v=2zn7izyj548

Link to YouTube https://www.youtube.com/watch?v=JsYcDM7XvHo

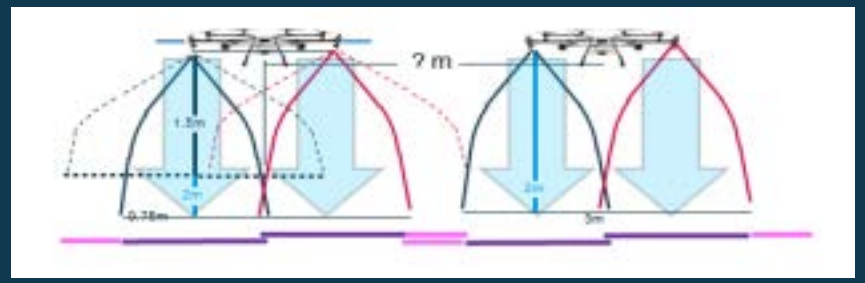
Web Siteより

USE

- Herbicide, Fungicide, Insecticide
- Fertilizer
- Seeds (Iron Coat)

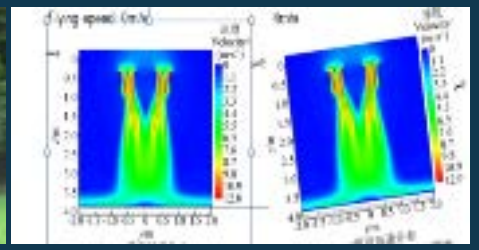
Clod

Testing Methodology – Spray Conditions

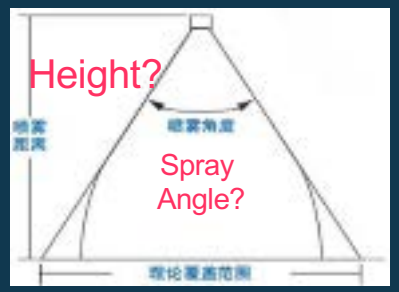


Spray Width?

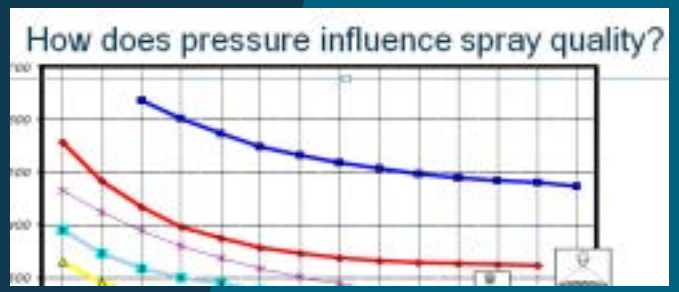
Wind Speed?



Flying Speed?



Flying Height?



Flow Rate?

GPS | RTK Compatible

Drone Type / Technology?

Standardized Testing Conditions

Spray Nozzle?

Efficacy – UAS Testing of Registered Products

>90 %

➢ Tested products are compatible with drone spray

20

BCS Product Tested

38

Crops / Application Methods Tested


rice


corn


sugarcane


banana


citrus


wheat

Efficacy for various diseases and insect pest in applied with UAS comparable to conventional

Results Comparable Effiacy UAS & Conventional is in line with recent J-MAF decision to waive extra UAS Efficacy Trial Requirement

UAS Ready Bayer Portfolio APAC

APAC DAT Team Field Testing

BCS products suitable for ULV by drone:

NATIVO

vayego

COUNCIL

Luna EXPERIENCE

Curbix

COUNCIL complete

Silvacur

MOVENTO

ADMIRE

Conditionally Suitable

Antracol

SIVANTO

Confidor

For 2019 testing

decis

BELT

Tested 23 BCS products; different variants, mixtures Insx+Funx

Human Safety: Operator Exposure – Conventional vs UAS

<u>Objective:</u> Are UAS spray applications safe to the Operator?
<u>Measure:</u> Benchmarking Backpack Sprayer & Drone Application with MARDI in MYS

// Operator
with conventional power sprayer

Study Design

Full Body Dosimeter Tracer Operator Exposure Study with MARDI (Malaysia) benchmarking conventional vs. UAS (OECD (97)148)

// Operator
with Drone remote control

Human Safety: Operator Exposure – Conventional vs Drone

Study parameters

Rice application in Malaysia in Dec 2017

Application methods used were drone and knapsack power sprayer

3 replicates per application method with tracer in 6 separate plots were conducted

Dermal exposure was determined via whole body dosimetry

Analytical determination of exposure via HPLC MS/MS detection

Summary of results mg a.i. / person

Drone	
Replicate 1	0.22
Replicate 2	0.11
Replicate 3	0.10
Mean	0.14

Power Sprayer	
Replicate 1	10
Replicate 2	23
Replicate 3	12
Mean	15

Result

Exposure with **Power Sprayer is >100** compared to **Drone**

Range of 45 up to 230 (min-max comparison)

Dietary Safety: Comparing Residue UAS & Backpack in Rice

Product 	Equipment 	Dose g/ha	Adjuvant	PHI (Days)	Residues (mg/kg)					
					UTC (50 m x 6 m)	Buffer	Backpack (50 m x 6 m)	Buffer	Backpack (50 m x 6 m)	Buffer	Drone (50 m x 16 m)
Untreated Control	-	-	-	-	<0.02	<0.02	<0.02	<0.01	<0.01	<0.01
Product	Backpack	100 %	-	21	0.08	<0.02	<0.02	0.70	0.28	0.11
Product	Backpack	100 %	50	21	0.08	<0.02	<0.02	0.96	0.28	0.10
Product	Drone	100 %	50	21	0.05	<0.02	<0.02	0.55	0.16	0.06

Result

UAS residues = conventional residues

Findings are in line with long term testing in Japan and recent decision to waive additional residue requirement

Environment: DoA & Bayer Drone Drift Exposure Trial

Investigate off target drift exposure from UAS

Drift Trial Outcome: Generic %-drift values per distance (3, 5, 10, 15, 20 m)

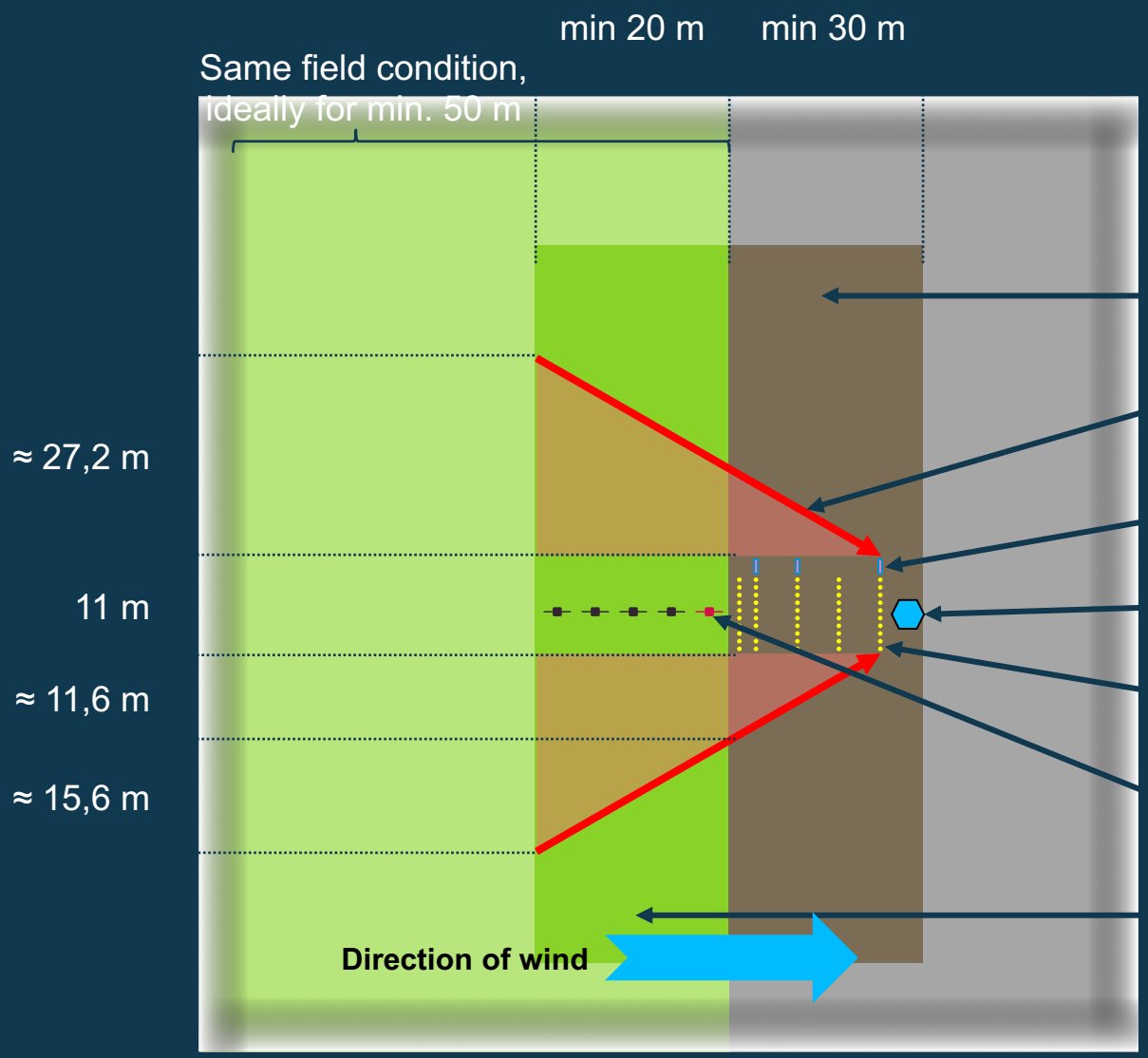
- **Field Facility:** Bayer Research Station at Suphanburi, Thailand
- **Test Item**: Kingcol Tartrazine = Generic Dye
- **Testing** Drone Applications on rice with (1) Standard Nozzle, (2) Drift Reducing Air Injector Nozzle, (3) Standard Nozzle & Silwet added to mixture
- **Analytics:** Dr. Pruetthichat , DOA, Thailand

Objective

Define safe use boundary conditions (wind height, speed) minimizing drift

Set label warning for off crops

Environment: DoA & Bayer Drone Drift Exposure Trial



Measurement area

Maximum deviation (30° on both sides)

Nylon strings (sampler for airborne drift measurement)

Weather station

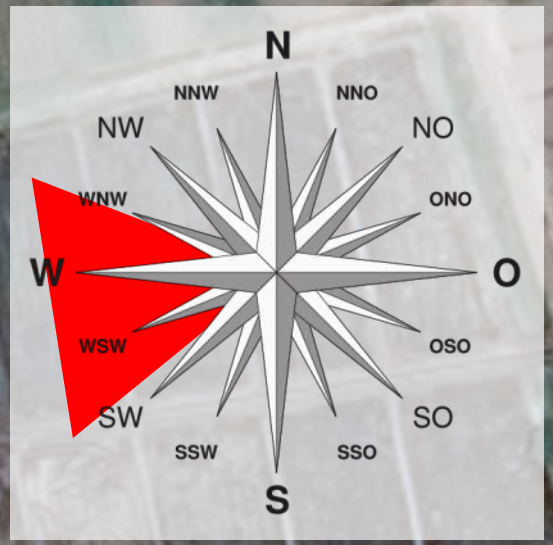
Block of petri dishes (sampler for ground drift measurement)

Sprayer = drone
multiple passes (20 m)

Treated area

Field - Wind direction

- Optimum wind direction:
  261.2°
  wind direction allowed (+/- 30°):
  231.2° - 291.2°



► maximum deviation (30°)

exactly West = 270°

Optimum wind direction

Human & Environmental Safety of UAS Applications

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	**Bio-Efficacy** Are efficacy levels as good as with conventional spraying ?	20 Products in 38 bio-efficacy trials in Thailand, China, Philippines, Malaysia, Indonesia in rice, corn, wheat (GEP-FAO)	**Efficacy** for various diseases and insect pest in rice, corn and wheat for **UAS comparable to conventional -> J-MAF abolished UAS efficacy trials**
	**Operator Safety** Can drone applications improve safety of the operator?	Full Body Dosimeter Tracer Operator Exposure Study with MARDI (Malaysia) benchmarking conventional vs. UAS (OECD (97)148)	UAS > **100 x lower Operator Exposure** than conventional spray gang
	**Dietary Safety** Are crop residues different due to low water volume applications?	Crop residue study in rice in Thailand benchmarking drone vs. conventional	**Residues** in rice for the same g/ha use rate in high volume backpack vs low volume are **comparable -> J-MAF abolished extra UAS residue trials**
	**Environmental Safety** How can drift be limited to avoid phytotox or undue environmental impact?	Spray Drift Exposure Trial (ISO 22866) and tracer analytics with DoA	Spray drift is much reduced by good agricultural practice observing wind speed, flight high, speed, nozzles

Regulatory Conclusions from Safety & Efficacy Trials

Japan has 30 years of experience in UAS trials & regulations
J-MAF concluded on *equivalence* of efficacy & residues after UAS & conventional at the same use rate

Data Requirement	Current	New Requirement (April 1, 2019 ~)
Efficacy Test	2 Trials/Target (Field trials, Different prefecture or different years)	Not required
Plant Compatibility Test	2 Trials/Target (Field trials, Different prefectures or years)	3 Trials/Crop (Pot trials are accepted, Different prefectures or years)
Crop Residue Test (Major crops)	3 Trials in a year (GLP)	Not required
Crop Residue Test (Semi-Major crops)	2 Trials in a year (Non-GLP)	Not required
Crop Residue Test (Minor crops)	2 Trials in a year (Non-GLP)	Not required

- J-MAF has announced to not require additional efficacy & residue trials for UAV if already available from conventional registrations
- Japanese regulations provide sophisitaced UAV Operational (SOP) guidance assuring safety

Suitable to Asian crops and farming practice, drones offer a revolutionary solution to modern agriculture challenges

Less water Volume
3% water volume of manual application

Comparable efficacy
Comparable or even better control efficacy VS manual

Cheaper Cost
50% treatment cost vs manual application

More efficient
30 times faster VS manual application

Safer to operator
Lower PPE requirements vs manual application

Labor Saving
Overcoming labor shortage

Thank you