POTENTIAL SPRAY DRIFT
EVALUATION OF AIRBLAST SPRAYER

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Currently, the unique standardized procedure officially recognized to assess spray drift amount generated by **PAE used in tree/bush crops**, and to classify their drift reduction performance is that provided by **ISO22866:2005**

**Difficulties to apply ISO field layout**

- Difficulties to find a suitable crop (rows orientation) in relation to the site-specific wind characteristics
- Bare soil parcel downwind to the sprayed area

**Difficulties to meet the atmospheric conditions required by ISO**

- **Air temperature between 5 and 35°C**
- **RH (no limitation)**
- **Wind speed**
  - Mean > 1 m s⁻¹
  - Minimum and maximum (no limitation)
  - Outliers (< 1 m s⁻¹) < of 10% of records (using 1Hz sampling frequency)
- **Wind direction**
  - Mean between 90 ± 30° azimuth (spray track)
  - Centered direction (no more than 30% of records shall be > 45° azimuth from the perpendicular of the spray track)
Difficult to obtain comparable and repeatable results useful for comparative PAE drift classification.

Only 50% of trials accomplish the environmental ISO requirements.
NEED TO DEVELOP AN ALTERNATIVE TEST METHOD TO PERFORM COMPARATIVE ASSESSMENT OF SPRAY DRIFT GENERATED BY AIRBLAST SPRayers

ALTERNATIVE TEST METHOD SMART AIMED TO EASILY AND PROPERLY CLASSIFY THE PAE AS A FUNCTION OF THEIR DRIFT REDUCTION PERFORMANCE

AVOIDING THE UNCONTROLLABLE VARIABLES THAT STRONGLY AFFECT FINAL RESULTS

ATMOSPHERIC CONDITIONS

↓

Overall wind effect

CROP TYPES

↓

• Canopy architecture
• Development
• Layout of plantation
• Training system
• Growth stage

Introduction | Materials and methods | Results and discussion | Conclusions
Currently for FIELD CROP SPRAYERS exist an alternative method to ISO22866:2005

ISO22401:2015
Equipment for crop protection- Methods for measurement of potential drift from horizontal boom sprayers systems by use of a test bench.
AIMS

DEVELOP A TEST METHOD ABLE TO ASSESS POTENTIAL SPRAY DRIFT OF THE DIFFERENT PAE USED FOR BUSH/TREE CROPS AND THEIR SETTINGS

DRIFT POTENTIAL
Relative drift values obtained from tests performed in NEARLY ABSENCE OF WIND and WITHOUT CROP/TARGET

NEARLY ABSENCE OF WIND to minimize the variability of results when comparative measurements were needed

ABSENCE OF TARGET very difficult to standardize an artificial target useful for all the bush/tree vegetation types and conditions.

Introduction  Materials and methods  Results and discussion  Conclusions
CURRENTLY IN ITALY OVER 1000 MODELS OF PAE USED IN BUSH/TREE CROPS ARE COMMERCIALIZED

POTENTIALLY EACH OF THEM SHALL BE TESTED TO DETERMINE THEIR PERFORMANCE IN DRIFT REDUCING (ISO16119-3:2013)

AN OBJECTIVE AND SMART METHODOLOGY FOR DRIFT EVALUATION/CLASSIFICATION OF PAE USED IN BUSH/TREE CROPS IS REQUIRED!!!

If sprayer settings are considered VERY HIGH NUMBER OF COMBINATIONS (PAE&Settings) HAVE TO BE EVALUATED!!!
Aim of test bench is to collect the free floating fraction of liquid sprayed that remains suspended over the bench and is potentially subject to drift (Drift Potential).
LAYOUT OF TEST

Automatic system for revealing the collectors after 4 s

Test bench

Maximum wind speeds below 1 m s\(^{-1}\)

- Only one sprayer's side activated
- Solution of yellow dye tracer – Tartrazine E102-
- Distance between outer nozzle/s and test bench equal to 1.5 m
- Spray application start 20 m before and stop 20 m after the test bench
- 40 Petri dishes collectors used in each replicate

5 replicates

- AT THE END- Laboratory analysis to determine the amount of tracer recovered
**DRIFT POTENTIAL VALUE CALCULATION (DPV)**

\[ DPV = \sum_{i=1}^{n} D_i \times Coeff \]

- **DPV** is the drift potential value used as adimensional number
- **\( D_i \)** is the spray deposit on a single deposit collector, in µL cm\(^{-2}\)
- **\( n \)** is the number of collectors (40)
- **Coefficient** is a variable coefficient based on the cumulative deposition curve obtained from the spray deposit measured on every single collector.
DRIFT POTENTIAL VALUE CALCULATION: 
(Coefficient calculation)

\[ \text{Coeff} = \sum_{n=1}^{10} Dst_{n \times 10} \]

- \( \text{Coeff} \) is the variable coefficient in m
- \( Dst_{n \times 10} \) corresponds to the value equal to the distance in meters from the outer sprayer nozzle where \( n \times 10 \% \) of the cumulative spray drift deposit calculated is achieved (i.e., from 10\% to 100\% in intervals of 10\%).
e.g. Sprayer settings A (conventional nozzles) and B (drift-reducing nozzles)

Sprayer settings A and B generate different potential drift curves, (different total deposition amount and displacement of deposits at the different distances from the sprayer)

**DRIFT POTENTIAL VALUE CALCULATION: (Coefficient calculation)**

**Introduction**

**Materials e methods**

**Results and discussion**

**Conclusions**
The higher the spray drift deposit accumulated close to the sprayer, the lower is the coefficient applied in the calculation of the DPV.

Setting A:
3.5+4.5+5.5+6+6.5+7.5+8.5+10+12.5+16
Coeff = 80.5

Setting B:
1.5+2+2+2.5+3+3.5+4+4.5+6+15
Coeff = 44.0

The COEFFICIENT REWARDS THE SPRAYER SETTINGS THAT ACCUMULATE THE HIGHEST AMOUNT OF SPRAY DRIFT CLOSE TO THE SPRAY SOURCE!!!
EVALUATION OF POTENTIAL DRIFT

THE WHOLE PROCEDURE

Adaptation of drift reduction (%) calculation method (ISO22369-1:2006):

\[
\text{DPV}_{\text{reference}} : 100 = \text{DPV}_{\text{candidate}} : X
\]

\[
\text{DPV}_{\text{reduction}} [%]=100-\left(100\times\frac{\text{DPV}_{\text{candidate}}}{\text{DPV}_{\text{reference}}}\right)
\]

Drift Potential Value (DPV) – obtained from the mean of DPV calculated for each replicate

CLASSIFICATION
following ISO22369-1:2006 classes

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TRIALS PERFORMED

REFERENCE PAE
Sprayer: Nobili Geo 90
Nozzles type and total flow rate:
• TXA8001VK (active n° 9 → 23.40 L min⁻¹)
Fan air volume: HIGH (51,000 m³ h⁻¹)
Forward speed: 6 Km/h

CANDIDATE PAE
Sprayer: Fede Qi90 Futur 2000
PAE SETTINGS
Nozzles types and total flow rate:
• ATR80 red (active n° 8 → 18.64 L min⁻¹)
• TVI80025 (active n° 8 → 17.92 L min⁻¹)
Fan air volume: HIGH (46,000 m³ h⁻¹), LOW (29,000 m³ h⁻¹)
Forward speed: 6 Km/h

Configurations: Nobili_TXA6H VS. Fede_ATR6H Fede_ATR6L Fede_TVI6H Fede_TVI6L

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TIME REQUIRED

- ≈ 1 minute required for spray application (6 km/h)
- 1 minute after spray application (time needed to allow the free floating droplets deposition)
- ≈ 4 minutes to collect and replace the 40 Petri dishes collectors (two operators)

TOTAL TIME REQUIRED FOR EACH REPLICATE
≈ 6 MINUTES

AGAINST

TOTAL TIME REQUIRED FOR EACH REPLICATE APPLYING ISO22866:2005
≈ 25 MINUTES

- ≈ 10 minutes required for spray application of 1000 m² in orchard (6 km/h, five rows of 60m length and distance between rows 4m)
- ≈ 4 minutes required for technical times (e.g. tractor maneuver, etc.)
- 1 minute after spray application (time needed to allow the free floating droplets deposition)
- ≈ 10 minutes to collect and replace the 60 Petri dishes collectors (two operators)

TEST BENCH METHOD REDUCES OF 33% THE NUMBER OF SAMPLES
# ATMOSPHERIC CONDITIONS

Mean data, based on 5 replicates (1Hz frequency)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Temperature MEAN [°C]</th>
<th>Relative Humidity MEAN [%]</th>
<th>Wind speed MEAN [m s⁻¹]</th>
<th>Wind speed MIN [m s⁻¹]</th>
<th>Wind speed MAX [m s⁻¹]</th>
<th>Wind direction MEAN [°azimuth]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Nobili_TXA6H</td>
<td>13.58</td>
<td>84.73</td>
<td>0.22</td>
<td>0.12</td>
<td>0.34</td>
<td>188</td>
</tr>
<tr>
<td>Candidate Fede_ATR6H</td>
<td>13.04</td>
<td>87.28</td>
<td>0.06</td>
<td>0.04</td>
<td>0.11</td>
<td>158</td>
</tr>
<tr>
<td>Candidate Fede_ATR6L</td>
<td>13.50</td>
<td>87.41</td>
<td>0.16</td>
<td>0.06</td>
<td>0.31</td>
<td>166</td>
</tr>
<tr>
<td>Candidate Fede_TVI6H</td>
<td>13.66</td>
<td>86.62</td>
<td>0.12</td>
<td>0.02</td>
<td>0.22</td>
<td>207</td>
</tr>
<tr>
<td>Candidate Fede_TVI6L</td>
<td>15.89</td>
<td>77.45</td>
<td>0.26</td>
<td>0.04</td>
<td>0.50</td>
<td>212</td>
</tr>
</tbody>
</table>

*relative to the spray track

- LOWER THAN 0.3 m s⁻¹
- LOWER THAN 0.5 m s⁻¹

Introduction  Materials and methods  Results and discussion  Conclusions
Spray deposit profiles (µL/cm²) obtained testing the reference and the candidates configurations.
The Coefficient is calculated for single replicate in order to obtain a DPV from each replicate.

<table>
<thead>
<tr>
<th>Configurations</th>
<th>Coefficient obtained in each replicate</th>
<th>MEAN</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Replicate 1</td>
<td>Replicate 2</td>
<td>Replicate 3</td>
</tr>
<tr>
<td>Reference Nobili_TXA6H</td>
<td>75.0</td>
<td>85.5</td>
<td>76.5</td>
</tr>
<tr>
<td>Candidate Fede_ATR6H</td>
<td>78.0</td>
<td>85.0</td>
<td>93.0</td>
</tr>
<tr>
<td>Candidate Fede_ATR6L</td>
<td>62.5</td>
<td>62.0</td>
<td>64.5</td>
</tr>
<tr>
<td>Candidate Fede_TVI6H</td>
<td>59.5</td>
<td>50.0</td>
<td>55.0</td>
</tr>
<tr>
<td>Candidate Fede_TVI6L</td>
<td>45.0</td>
<td>52.0</td>
<td>41.5</td>
</tr>
</tbody>
</table>
DRIFT POTENTIAL VALUES (DPVs)

DPVs obtained and bars ± SE of the mean; the dots shown the drift reduction (%) achieved by each candidate configuration relative to the reference configuration.
DRIFT REDUCTION VALUES OBTAINED (ISO22361-1:2006)

<table>
<thead>
<tr>
<th>Configurations</th>
<th>Drift reduction (%)</th>
<th>Drift reduction class achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Nobili_TXA6H</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Candidate Fede_ATR6H</td>
<td>30,4</td>
<td>F</td>
</tr>
<tr>
<td>Candidate Fede_ATR6L</td>
<td>73,6</td>
<td>E</td>
</tr>
<tr>
<td>Candidate Fede_TVI6H</td>
<td>90,1</td>
<td>C</td>
</tr>
<tr>
<td>Candidate Fede_TVI6L</td>
<td>95,2</td>
<td>B</td>
</tr>
</tbody>
</table>

Potential spray drift reduction (%) and classes of reduction achieved by PAE configurations tested according with ISO22369-1 (A ≥ 99 %, B 95 % ≤ 99 %, C 90 % ≤ 95 %, D 75 % ≤ 90 %, E 50 % ≤ 75 % and F 25 % ≤ 50 %.)
These preliminary studies introduce a proposal of a simple procedure for assessing the DPV of airblast sprayer.

The candidate PAE adjustment tested (combination of nozzles type and fan air flow rate) show an effect in drift potential reduction, as expected.

These first promissory results, give a concrete possible alternative to ISO22866:2005 for the drift reduction classification of airblast sprayers in a simple and repeatable way.
...investigate the most properly setting of opening time of the test bench as a function of the sprayer forward speed tested. DPV and spray drift reduction need to be evaluated in a wide range of forward speeds.

...investigate the suitability of the test bench to detect the spray drift potential from further types of air blast sprayers (i.e. pneumatic and cross flow fan sprayers).

...compare the spray drift potential risk obtained using the test bench (indirect method) and the spray drift risk obtained by applying the ISO22866:2005 field test method (direct method).
Thanks for your attention!!!