The dose expression dilemma.
State of the art in Europe

P. Balsari, E. Gil

DISAFA University of Turin
UPC- Universitat Politecnica de Catalunya

AAB - Dose Expression Workshop – Barcelona, November 2018
1. Background
2. Current dose expression units
3. The necessity to refer the dose to the real target surface
4. The Leaf Wall Area (LWA) dose expression system: benefits ad gaps still to be covered
5. Some considerations
6. Conclusion
7. Q&A
1. Background (terms & definitions)

Dose expression: The unit in which the dose is expressed (i.e.: L/ha – g/L)

Dose rate: The amount of product necessary to achieve the required efficacy

Dose rate adjustment: The Dose rate periodical adjustment in function of the target surface development or the disease pression

Volume rate: The amount of water used to apply the requested dose

Volume rate adjustment: The Volume rate periodical adjustment in function of the target surface development

Amount of pesticide for target unit: Amount of pesticide that reach and remain on the target (µl/cm²)
1. Background

Pesticide AI efficacy

- Environmental conditions
  - Temperature
  - RH
  - Wind speed and direction

- Application methods

- Type of sprayer and adjustment

- Effective amount of pesticide per target unit ($\mu l/cm^2$)

- Amount of PPP applied

- Dose rate

- Volume rate
1. Background

Pesticide application on field crops

- Target surface generally well known
- Not large crop (target surface) difference along treatment periods
- EU common dose rate expression (l or kg/ha)
- Generally reduced out of the target pesticide application
Limited difficulties in determining Pesticide efficacy and Risk assessment.

1. Background

Evaporation (3-4%) vs. Drift losses (6-8%)

On the target (up to 90%)
- Target surface not well defined and known
- Big difference target surface between the same crops and along treatment periods
- No common EU dose rate expression
- Generally high out of target pesticide application
1. Background

- Drift losses and out of the target (10-15%)
- Evaporation losses (4-6%)
- Ground losses (30-60%)
- On the target (19-56%)

High difficulties in determining

Pesticide efficacy

Risk assessment
Vineyard training systems in Spain
The vineyard training systems more spread in Italy are:

- **TENDONE**: 21%
- **ALBERELLO**: 20%
- **GUYOT**: 15%
- **SYLVOZ/CASARSA**: 7%
1. Background

Example of the target surface according to the training system (measured at the ripening of berries growth stage, BBCH = 81)
1. Background

EXAMPLE OF THE EVOLUTION OF THE CANOPY SIZE IN A VINEYARD GUYOT TRAINED

Inflorescence emerge (BBCH 57)

Development of fruits (BBCH 75)

Ripening of berries (BBCH 81)
1. Background

LAI according to the different training systems

![Graph showing LAI values for different training systems (Tendone, Alberello, Guyot, Casarsa). The y-axis represents LAI values ranging from 0.0 to 3.5, and the x-axis represents the training systems.]
Total leaf surface according to the variety and the evaluation period

PIEMONTE - GUYOT
layout 2.8 X 1.0
3571 plants /ha

Results of tests made by DISAFA Univ.Torino
1. Background

Amount of product on the leaves according to the leaf surface of the vineyard **distributing the same volume of water** *(Dose if the concentration is constant)*

![Graph showing the relationship between total leaf area (m²/ha) and quantity of product on the leaves (µl/cm²).](image)

*Results of the tests made by DISAFA Univ.Torino*
Leaf Wall Area (LWA) for vineyard trellis systems.

(20 years of experience at Universitat Politècnica de Catalunya)
2. Current dose rate expression for 3D crops

Main current dose expression unit

- **Concentration of pesticide in water**
  \( (L \text{ or } kg/hL) \)

- **Target surface**
  \( (Kg \text{ or } L / -m \text{ of canopy height} - LWA - \text{Row Length}) \)

- **Target volume**
  \( (Kg/m^3 \text{ TRV}) \)

- **High differences in specific unit of dose applied between EU due to the different reference volume and for the same crop due to the differences in training system and layout**

- **Generally not related to the crop target surface and its seasonal development**

Consider the target surface/volume
2. Current dose rate expression for 3D crops

Main current dose expression unit

- Concentration of pesticide in water (L or kg/hL)
  - Easy to adopt
  - Mostly used in southern EU
  - Poor target addressed
  - High risk of over or under dosage

- Target surface (Kg or L / - m of canopy height – LWA - Row Length)
  - Not always easy to adopt
  - Mostly used in central – northern EU
  - Target addressed
  - Lower risk of over or under dosage

- Target volume (Kg/m³ TRV)
Volume rate
(Present situation in South EU)

Dose expression = concentration (Kg or L/hL)

Reference volume (L/ha) could vary considerably also in the same country for different crops (e.g.: Italy- 1000 L/ha for vineyard – 1500 L/ha for orchard)

These volume rates are generally not more used

Concentration values are consequently increased

E.g.: - Reference volume 1000 L/ha concentration = X
      - Real volume 200 L/ha concentration = 5 X
The contradiction of the dose expression based on [x]
The Spain example
Anti mildiu product

The contradiction of the dose expression based on [x] - The Spain Example

<table>
<thead>
<tr>
<th>CULTIVO</th>
<th>ENFERMEDAD</th>
<th>TIPO DE APLICACIÓN</th>
<th>DOSIS RECOMENDADA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cebolla</td>
<td>Mildiu</td>
<td>Aplicar en pulverización foliar normal, mojando uniformemente la parte aérea del</td>
<td>200-300 g por 100 l de agua. Max. 2,5 kg/ha</td>
</tr>
<tr>
<td>Lechuga</td>
<td>Mildiu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pepino</td>
<td>Mildiu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patata</td>
<td>Alternariosis y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tabaco</td>
<td>Moho azul</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomate</td>
<td>Alternariosis,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mildiu y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomate</td>
<td>Septoriosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viña</td>
<td>Mildiu</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

El número máximo de tratamientos por campaña será de 4 en viña y 3 en el resto de cultivos. Los tratamientos deberán iniciarse al comienzo del período de crecimiento, de forma preventiva, antes del establecimiento de la enfermedad. Para ello se pueden seguir las recomendaciones de las Estaciones de Avisos. El intervalo máximo entre las aplicaciones será de 14 días. En condiciones muy favorables al desarrollo del mildiu, reducir el intervalo a 10 días, especialmente en las fases de mayor crecimiento del cultivo. En viña el último tratamiento se realizará, como mucho tarde, 14 días después del final de la floración.

- Who applies 1000 l/ha?
- [200 – 300 g/100 l] works properly?
- Only for 1000 l/ha?
- What happens if volume/ha is adjusted and spray coverage improved?
2. Current dose rate expression for 3D crops in Europe

**Reference units in the EU:**

- ground area
- spray volume (concentration %)
- canopy height - CH
- leaf wall area - LWA
- tree row volume - TRV
- plant row

*(Doruchowski 2017)*
2. Current dose rate expression for 3D crops in Europe

Reference units in the EU: SE, DK, FI, LT • CZ, HU, PL, SI, SK, UK • FR

- ground area
- spray volume (concentration)
- canopy height - CH
- leaf wall area - LWA
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(Doruchowski 2017)
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- canopy height - CH
- leaf wall area - LWA
- tree row volume - TRV
- plant row

**kg or L/100 L spray volume (%)**
+ spray volume (max)
and/or + max dose/ha ground

(Doruchowski 2017)
2. Current dose rate expression for 3D crops in Europe

**Reference units in the EU:**

- ground area
- spray volume (concentration)
- canopy height - CH
- leaf wall area - LWA
- tree row volume - TRV
- plant row

**kg or L/ha ground** and **m CH**

*(Doruchowski 2017)*
2. Current dose rate expression for 3D crops in Europe

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- leaf wall area - LWA
- tree row volume - TRV
- plant row

\[
LWA = 2 \times \frac{\text{canopy height [m]}}{\text{row spacing [m]}} \times 10000 \, \text{m}^2
\]

(Doruchowski 2017)
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\[
TRV = \frac{\text{canopy height [m]} \times \text{canopy width [m]}}{\text{row spacing [m]}} \times 10000 \text{ m}^2
\]

(Doruchowski 2017)
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- ground area
- spray volume (concentration)
- canopy height - CH
- leaf wall area - LWA
- tree row volume - TRV
- plant row

(kg or L/100 m di filare)

(Doruchowski 2017)
Dose expression and volume rate have been key factors widely discussed in the recent years, unfortunately without a clear and unique EU recommendation.
## 2. Current dose rate expression in Europe

<table>
<thead>
<tr>
<th></th>
<th>Orchard</th>
<th>Vineyard</th>
<th>High-growing vegetables</th>
<th>Citrus / Olives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria and Germany</td>
<td>Kg/ha/m of canopy height (max kg/ha)</td>
<td>% accord. Eichhorn, max. kg/ha BBCH</td>
<td>Kg/ha/m of canopy height (max kg/ha)</td>
<td>---</td>
</tr>
<tr>
<td>Belgium</td>
<td>Kg or L /10'000m² LWA, max.kg or l /ha</td>
<td>---</td>
<td>Kg/ha</td>
<td>---</td>
</tr>
<tr>
<td>France</td>
<td>Kg/ha</td>
<td>Kg/ha</td>
<td>Kg/ha</td>
<td>---</td>
</tr>
<tr>
<td><strong>Switzerland</strong></td>
<td>Kg/10'000 m³ TRV</td>
<td>%, max. spray vol / ha</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>---</td>
</tr>
<tr>
<td>Norway</td>
<td>Kg/100m row length</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>---</td>
</tr>
<tr>
<td>Greece</td>
<td>(A) Concentration = L-kg/Hi) (Min to max spray volume /ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
</tr>
<tr>
<td>Italy</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
</tr>
<tr>
<td>Portugal</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
</tr>
<tr>
<td>Spain</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
<td>(A) Concentration = L-kg/Hi) (Max vol/ha)</td>
</tr>
</tbody>
</table>

6 different dose expression units for orchard!
Need of Harmonisation of dose expression

EPPO General Standard PP 1/239(2)

Dose expression for crop protection products

• “........ The dose should be expressed in a form easily understood by users of plant protection products”

• Reference units for crops (3D) listed and discussed (EPPO Vienna meeting 2017):
  
  - Ground area
  - Spray volume (concentration %)
  - Canopy height – CH
  - Leaf wall area (– LWA) x vineyard
  - Tree row volume (–TRV)
  - Plant row
4. The Leaf Wall Area (LWA) dose expression system

The principle

To adapt the pesticide dose to the ‘mass’ of the target following the pharmaceuticals raccomandations dose principle
Pharmaceuticals: dose rate adapted to the body weight

- 15 kg child
- 55 kg lady - teacher
- 100 kg worker
Agriculture: dose rate should be adapted to the size of the crop

(Principle: foliar applications should result in similar deposits per e.g. μl/cm² or ng/cm²)
4. The Leaf Wall Area (LWA) dose expression system

Leaf Wall Area calculation

Leaf Wall Area (LWA) $m^2 = 2 \times \text{Canopy height (m)} \times \frac{\text{Ground area (m}^2)}{\text{row distance (m)}}$
## 4. The Leaf Wall Area (LWA) dose expression system

### A possible future label

(Examples of LWA for pome fruit orchards)

<table>
<thead>
<tr>
<th>Row distance (m)</th>
<th>Canopy or foliage height (m)</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>2.5</td>
<td>12'000</td>
<td>16'000</td>
<td>20'000</td>
<td>24'000</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>3.0</td>
<td>2.5</td>
<td>10'000</td>
<td>13'333</td>
<td>16'666</td>
<td>20'000</td>
<td>23'333</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>3.5</td>
<td>3.0</td>
<td>8'571</td>
<td>11'428</td>
<td>14'286</td>
<td>17'143</td>
<td>20'000</td>
<td>22'857</td>
<td>n.a.</td>
</tr>
<tr>
<td>4.0</td>
<td>3.5</td>
<td>7'500</td>
<td>10'000</td>
<td>12'500</td>
<td>15'000</td>
<td>17'500</td>
<td>20'000</td>
<td>22'500</td>
</tr>
<tr>
<td>4.5</td>
<td>4.0</td>
<td>6'666</td>
<td>8'888</td>
<td>11'111</td>
<td>13'333</td>
<td>15'555</td>
<td>17'777</td>
<td>20'000</td>
</tr>
<tr>
<td>5.0</td>
<td>4.5</td>
<td>6'000</td>
<td>8'000</td>
<td>10'000</td>
<td>12'000</td>
<td>14'000</td>
<td>16'000</td>
<td>18'000</td>
</tr>
</tbody>
</table>

= most common sizes for modern pome fruit orchards

LWA expression way

<table>
<thead>
<tr>
<th>Product:</th>
<th>Kg, L / 10,000 m² LWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume:</td>
<td>L / 10,000 m² LWA</td>
</tr>
</tbody>
</table>
LWA expression: still several main aspects need to be defined

How to appropriate determine LWA

How to determine the VOLUME related to LWA

How to convert «old» dose expression systems to LWA

4. The Leaf Wall Area (LWA) dose expression system
4. The Leaf Wall Area (LWA) dose expression system

Measurement of the Canopy Height

e.g. 50 cm
Area between white lines is the treated area or Leaf Wall Area ??
4. The Leaf Wall Area (LWA) dose expression system

Leaf Wall Area (measured) = Leaf Wall Area treated ??
4. The Leaf Wall Area (LWA) dose expression system

Area between white lines is the Treated Canopy Height
4. The Leaf Wall Area (LWA) dose expression system

Example: Pome fruit orchard trained at «Vaso» system

H = Treated Canopy Height
D = Row spacing
4. The Leaf Wall Area (LWA) dose expression system

Example: Vineyard trained at trellis system

H = Treated Canopy Height
Only sprayed canopy height is relevant
should reflect the height of treated area (trunk to be disregarded)
Average on 10 most representative grapevines of the trial is recorded

D = Row Spacing

photo: Agroscope viti 2005/6
4. The Leaf Wall Area (LWA) dose expression system

Example: Vineyard trained at «Pergola» system

$H1 + H2 = \text{Treated Canopy Height}$

Only sprayed canopy height is relevant. It should reflect the height of the treated area (trunk to be disregarded). The average is calculated on 10 most representative grapevines from the trial.
4. The Leaf Wall Area (LWA) dose expression system

- Moving from Leaf Wall Area (LWA)
- TO Leaf Treated Wall Area (LTWA)

Standardized methods of LWA measurements are necessary!!
4. The Leaf Wall Area (LWA) dose expression system

Main aspects still to be defined/achieved

MAX Leaf Wall Area (LWA) value

Reference Volume rate × LWA

Conversion formula from the current used dose expression units to LWA and vice versa
4. The Leaf Wall Area (LWA) dose expression system (main aspects to be defined/achieved)

Max LWA value

Maximum leaf wall area - Impact on product /ha

From R.D. Toews – Bayer Application Technology Group
4. The Leaf Wall Area (LWA) dose expression system

**LWA** per country & zone (Chemical industry Data)

**Orchard**

- Max LWA: (5000.00 <= Max LWA <= 30000.00) and empty values
4. The Leaf Wall Area (LWA) dose expression system

Apple + pear: distribution of LWA in regulatory zones

Analysis by Peter Lancashire (SAS 9.2 on 14OCT2011 at 10:15) © Bayer CropScience AG
The source data come from efficacy and residue trials in Europe from 2003-2011.
Key: line=median, diamond=mean, box=half data, whisker=box±1.5, points=outliers.
4. The Leaf Wall Area (LWA) dose expression system

**Distribution of LWA by Fruit Trees groups (all countries together)**

<table>
<thead>
<tr>
<th>Crop name</th>
<th>N Obs</th>
<th>Mean</th>
<th>90th Pctl</th>
<th>95th Pctl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>900</td>
<td>13462</td>
<td>18462</td>
<td>20000</td>
</tr>
<tr>
<td>Pear</td>
<td>321</td>
<td>13465</td>
<td>18400</td>
<td>20000</td>
</tr>
<tr>
<td>Apricot</td>
<td>39</td>
<td>9200</td>
<td>12000</td>
<td>12941</td>
</tr>
<tr>
<td>Nectarine</td>
<td>59</td>
<td>8770</td>
<td>13333</td>
<td>15000</td>
</tr>
<tr>
<td>Peach</td>
<td>238</td>
<td>9565</td>
<td>12500</td>
<td>14222</td>
</tr>
<tr>
<td>Cherry</td>
<td>149</td>
<td>11353</td>
<td>15429</td>
<td>17143</td>
</tr>
<tr>
<td>Plum</td>
<td>134</td>
<td>11614</td>
<td>15556</td>
<td>17143</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop group</th>
<th>N Obs</th>
<th>Mean</th>
<th>Lower 95% CL for Mean</th>
<th>Upper 95% CL for Mean</th>
<th>25th Pctl</th>
<th>50th Pctl</th>
<th>75th Pctl</th>
<th>90th Pctl</th>
<th>95th Pctl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pome</td>
<td>1221</td>
<td>13463</td>
<td>13254</td>
<td>13671</td>
<td>10667</td>
<td>13333</td>
<td>15152</td>
<td>18462</td>
<td>20000</td>
</tr>
<tr>
<td>Stone</td>
<td>619</td>
<td>10340</td>
<td>10079</td>
<td>10601</td>
<td>8000</td>
<td>10000</td>
<td>12500</td>
<td>15000</td>
<td>15556</td>
</tr>
</tbody>
</table>

Analysis by Peter Lancashire (SAS 8.2 on 14OCT2011 at 10:15) © Bayer CropScience AG

The source data come from efficacy and residue trials in Europe from 2003-2011.

Key: line=median, diamond=mean, box=half data, whisker=box±1.5, points=outliers.
Germany Authorities & Advisory service proposal:  
18000 m²/ha (worst case scenario)  
Bayer proposal: 15000 m²/ha or country specific  
Chemical Industries proposal*: 20000 m²/ha

* Dummersdorf, June 2012

Necessity to find an harmonized value

NOTE: For small 3D canopy e.g. ‘Alberello’ trained vineyard need to define also a ‘minimum LWA value’ (e.g. 2000-3000 m²/ha) to avoid under dosage
4. The Leaf Wall Area (LWA) dose expression system

Vine plant: HOW TO CONSIDER THE EFFECT OF THE TOPPING / LEAF STRIPPING ON THE DEPOSITS AND THEREFORE TO DETERMINE THE DOSE USING LWA ??

Results of the tests made by DISAFA Univ.Torino

Quantity of product on the leaves (µl/cm²) before and after the topping

Total leaf area (m²/ha)
4. The Leaf Wall Area (LWA) dose expression system (main aspects to be defined/achieved)

**Reference Volume rate x LWA**

**Essential parameter**

### IMPORTANCE OF SOME PARAMETERS IN FUNCTION OF THE TARGET TYPE

Results of test made by DISAFA Univ. Turin

<table>
<thead>
<tr>
<th></th>
<th>Leaves</th>
<th>Bunches</th>
<th>Grape-stalk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayer type</td>
<td>n.s.</td>
<td>***</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>Volume applied</strong></td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Air flow rate</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Training system</td>
<td>n.s.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Growth stage</td>
<td>***</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Leaf position</td>
<td>***</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Time of topping off</td>
<td>n.s.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Key: *** = very significant, n.s. = not significant, - = parameter not examined
**4. The Leaf Wall Area (LWA) dose expression system**  
(main aspects to be defined/achieved)

Low Volume rates generally allow to obtain higher spray deposit on the target

<table>
<thead>
<tr>
<th>VOLUME (l/ha)</th>
<th>Spray deposit leaves (µl/cm²)</th>
<th>Spray deposit bunches (µl/g)</th>
<th>Spray deposit grape-stalk (µl/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0.427a</td>
<td>0.903a</td>
<td>3.767a</td>
</tr>
<tr>
<td>400</td>
<td>0.347b</td>
<td>0.669b</td>
<td>2.437b</td>
</tr>
<tr>
<td>600</td>
<td>0.305c</td>
<td>0.534b</td>
<td>1.295c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPRAYER TYPE</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-assisted</td>
<td>0.357ns</td>
<td>0.784a</td>
<td>2.604ns</td>
</tr>
<tr>
<td>Pneumatic</td>
<td>0.369ns</td>
<td>0.471b</td>
<td>2.190ns</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AIR FLOW RATE</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.397ns</td>
<td>0.857a</td>
<td>2.420ns</td>
</tr>
<tr>
<td>Medium</td>
<td>0.360ns</td>
<td>0.818ab</td>
<td>2.660ns</td>
</tr>
<tr>
<td>High</td>
<td>0.313ns</td>
<td>0.657b</td>
<td>2.733ns</td>
</tr>
</tbody>
</table>

All values normalised to 400 l/ha – Tests made by DISAFA Univ Turin
4. The Leaf Wall Area (LWA) dose expression system
(main aspects to be defined/achieved – Reference Volume rate)

Volume rate referred to LWA

Still few experimental data available!!

First suggestion

$150 \div 400 \, L \times 10,000 \, LWA/ha$
AMOUNT OF LIQUID ABLE TO DEPOSIT ON THE CANOPY IN CORRESPONDENCE OF DIFFERENT LWA VALUES
(DISAFRA TESTS IN NORTHERN ITALIAN VINEYARDS)

PROBABLY IT IS BETTER TO REFER THE VOLUME RATE (L/ha) TO AT LEAST 2 VINEYARD GROWTH STAGES:

- < 5000 m²/ha LWA = 75 ÷ 175 L/ha
- 5000 ÷ 10000 m²/ha LWA = 200 ÷ 400 L/ha
Which is the optimal volume rate?

0.037 l/m² LWA

- Optimal deposition
- Optimal coverage
- Optimal distribution
- Low drift losses

Italian suggestion: 5000 LWA = 175L/ha
10,000 LWA = 400 L/ha

Spain suggestion: 5000 LWA x 0.037 = 185 L/ha
10,000 LWA x 0.037 = 370 L/ha

With a very well adjusted sprayer!!
250 g per 100 l
Max. 2,5 kg/ha

1000 L/ha

5000 x 0.037 = 185 L/ha

5000 m² LWA/ha

REFERENCE VOLUME RATE x LWA.
(20 years of experience at Universitat Politècnica de Catalunya)
REFERENCE VOLUME RATE x LWA.
(20 years of experience at Universitat Politècnica de Catalunya)

350 L/ha

312 g → 12.5 %

437 g → 17.5 %

500 L/ha

625 g → 25.0 %

REFERENCE VOLUME RATE x LWA.
(20 years of experience at Universitat Politècnica de Catalunya)

1000 l/ha (LWA)

370 l/ha (LWA)

370 l/ha (LWA)
**REFERENCE VOLUME RATE**

**EXAMPLES OF CALCULATION OF THE SPRAY VOLUME ACCORDING TO DIFFERENT PLANT PARAMETERS APPLIED TO:**

**Vineyard : Pinot Nero**  
**Training system: Casarsa**  
**Growth stage: ripening of berries (BBCH 81)**  
**Row size:**  
- **1.5 m (height)**  
- **1.5 m (width)**  
- **0.9 m (height of vegetation from the ground)**  
**Inter row distance: 3.0 m**

**LWA = 4000 m^2/ha**  
**LAI = 2.6**  
**TRV = 7500 m^3/ha**  
**SU = 5.0**  
**Total canopy Surface (TCS) = 26180 m^2/ha**
CALCULATION OF THE SPRAY VOLUME CONSIDERING THE LEAF WALL AREA (LWA)

PROBABLY IT IS BETTER TO REFER THE VOLUME RATE (L/ha) TO AT LEAST 2 VINEYARD GROWTH STAGES:

< 5000 m²/ha LWA = 75 ÷ 175 L/ha
5000 ÷ 10000 m²/ha LWA = 200 ÷ 400 L/ha

LWA = 4000 m²/ha = Volume 175 l/ha
CALCULATION OF THE SPRAY VOLUME CONSIDERING THE LEAF AREA INDEX (LAI)

\[ V \, (l/ha) = \frac{2 \times LAI \times D_i \times \frac{4}{3} \times \pi \times \left(\frac{VMD}{2}\right)^3 \times 10^{-7}}{R} \]

\( V \) = volume application rate

\( LAI \) = leaf area index

\( D_i \) = optimal density of droplet impacts \((n/cm^2)\)

\( D_v \) = droplets volume

\( R \) = recovery factor on the target \((70 \div 75\%)\)
CALCULATION OF THE SPRAY VOLUME CONSIDERING THE LEAF AREA INDEX (LAI)

LAI = 2.6

VMD = 210 µm (medium droplet size)

Di = 120 (contact insecticide)

R = 70%

\[
V (\text{l/ha}) = \frac{2 \times 2.6 \times 120 \times \frac{4}{3} \times \pi \times (\frac{210}{2})^3 \times 10^{-7}}{0.7} = 430 \text{ l/ha}
\]
CALCULATION OF THE SPRAY VOLUME CONSIDERING THE TREE ROW VOLUME (TRV)

Input:
- Tree height \([ T ]\) = 1.5 m
- Canopy width \([ C ]\) = 1.5 m
- Inter-row width \([ R ]\) = 3.0 m

Vegetation volume \((Vv)\) = \(\frac{T \times C \times 10000}{R}\) = \(\frac{1.5 \times 1.5 \times 10000}{3}\) = 7500 m³/ha

Spray volume \((Vt)\) = \(\frac{Vv \times i}{1000}\) = \(\frac{7500 \times 70}{1000}\) = 525 l/ha

Volume index \((i)\)
- very high = 120
- high = 100
- medium = 70
- low = 50
- very low = 30
- ultra low = 10
CALCULATION OF THE SPRAY VOLUME CONSIDERING THE SURFACE UNIT (SU)

Reference volume (l/ha)  SU (m²/m²)

300  2.5

Actual SU = 5.0

Considering the experimental correlation between SU and volume rate, the spray volume should be equals to 370 l/ha.
CALCULATION OF THE SPRAY VOLUME CONSIDERING THE TOTAL CANOPY SURFACE (TCS)

Reference spray deposit: 0.5 µl/cm²

Total spray deposit on the canopy = 
0.5 µl/cm² x 26180 m² (total canopy surface) = 
130 litres

Percentage of spray volume recovered in correspondence of a total canopy surface of 25000 m²/ha = 40%

Spray volume = 330 l/ha
DIFFERENCES BETWEEN THE SPRAY VOLUMES CALCULATED

<table>
<thead>
<tr>
<th></th>
<th>LWA</th>
<th>LAI</th>
<th>TRV</th>
<th>SU</th>
<th>TCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume rate (l/ha)</td>
<td>175</td>
<td>430</td>
<td>525</td>
<td>370</td>
<td>330</td>
</tr>
</tbody>
</table>
Volume rate: moving from TRV to LWA for vineyard
(20 years of experience at Universitat Politècnica de Catalunya)

\[ Y = 0.042X - 538.89 \]

TRV = 1473 m³/ha

Ex. 5000 m² LWA/ha

0.12 l/m³ TRV

185 l/ha

0.037 l/m² LWA
4. The Leaf Wall Area (LWA) dose expression system (main aspects to be defined/achieved)

Conversion formula from the current used dose expression units to LWA & vice versa

Always possible ??

Model

Simplified formula

ARM Syngenta

UPC Disc
4. The Leaf Wall Area (LWA) dose expression system (main aspects to be defined/achieved)

Conversion formula from the current used dose expression units to LWA & vice versa

Tree row volume (kg per 10 000 m³ TRV)

Mid-width of crown (m)

Leaf wall area (kg per 10 000 m² LWA)

Row distance (m)

Leaf wall height (kg per ha and m CH)

Concentration (%)

Spray volume (L ha⁻¹)

Dose (kg ha⁻¹)

Spray volume (L ha⁻¹)

Leaf wall height

Canopy height (m)

EPPO Standard PP1/239(2) after: Frießleben et al., 2007.
4. The Leaf Wall Area (LWA) dose expression system
(main aspects to be defined/achieved – Conversion formula)

<table>
<thead>
<tr>
<th>Conversion Formula</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conversion to rate per ha ground area</strong></td>
<td></td>
</tr>
<tr>
<td>( \text{rate}_{GA} = \frac{X \times LWA}{10000} )</td>
<td>( \text{rate}_{GA} = \frac{0.8 \times 17500}{10000} )</td>
</tr>
<tr>
<td><strong>Conversion to rate per hl</strong></td>
<td></td>
</tr>
<tr>
<td>( \text{rate}_{HL} = \frac{x \times LWA}{SPV \times 100} )</td>
<td>( \text{rate}_{HL} = \frac{0.8 \times 17500}{1500 \times 100} )</td>
</tr>
<tr>
<td><strong>Conversion to rate per ha ground area and per m foliage height</strong></td>
<td></td>
</tr>
<tr>
<td>( \text{rate}_{FH} = \frac{x \times 2}{\text{row distance}} )</td>
<td>( \text{rate}_{FH} = \frac{0.8 \times 2}{4.0} )</td>
</tr>
</tbody>
</table>
4. The Leaf Wall Area (LWA) dose expression system (main aspects to be defined/achieved – Conversion formula)
4. The Leaf Wall Area (LWA) dose expression system (main aspects to be defined/achieved - conversion formula)

**Conversion formula from the current used dose expression units to LWA & vice versa**

Excel Tool for dose conversion

- request from Organising Committee of EPPO Workshop:

<table>
<thead>
<tr>
<th>Spray volume [l/ha]</th>
<th>Concentration [%]</th>
<th>Ground Dose [kg/ha]</th>
<th>CH Dose [kg/ha/m²]</th>
<th>LWA Dose [kg/10000 m²LWA]</th>
<th>TRV Dose [kg/10000 m²TRV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>300,00</td>
<td>0,15</td>
<td>0,450</td>
<td>0,150</td>
<td>0,263</td>
<td>0,438</td>
</tr>
<tr>
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<td>0,15</td>
<td>0,450</td>
<td>0,150</td>
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**Dose converter**
A common dose rate expression in 3D crops is essential due to the necessity to:

- Consider the real target surface and its characteristic related to crops layout-variety-training system and growing season
- Avoid the present big difference between countries
- Allow better and faster comparison and understanding of expression data across EU
- Facilitate the communication with or between regulatory bodies
- Fulfill the SUD and the NAP’S requirements of reducing the use of PPP thanks to a more precise application
LWA dose rate expression is probably the more suitable system but still several questions are open:

• *Is it useful for all 3D crops??* (what about small – ornamental- and big crops: Citrus-Poplar)

• *How to transform dose rate from currently dose expression unit to LWA??*

• *How shall be changed the previous PPP registration documents* (e.g.: residue and operator exposure) *when using LWA??*

• *How to refer volume rate to LWA??*

• *How shall be make a PPP label with LWA??*

• *How and who will be in charge to train the farmer to appropriate use LWA??*
LWA – DOSE expression in 3D crops

Several «open points» still exists also for LWA adoption in Vineyards

More coordinated research activities are needed

Work in progress
THANKS FOR ATTENTION

/ha Leaf wall area LWA

/ha and m of canopy height

/ha area

/10000 m3 rows volume TRV