Effects of *Asparagus virus 1* (AV-1) on yield and quality components

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Outline

• Introduction of *Asparagus virus 1* (AV-1) on asparagus
• Monitoring of AV-1 infection in Europe and America
• Experimental design to investigate AV-1 effects
• Results
• Summary and outlook
Introduction of *Asparagus virus 1* (AV-1) on asparagus

- AV-1 is one of the most important viruses in asparagus
- Its main vector is the green peach aphid (*M. persicae*)

Known effects of AV-1 in asparagus

- No visible disease symptoms
- Yield reduction 20 – 70 % (Yang 1979, Kegler et al. 1991)
- Susceptibility to *Fusarium* (Evans & Stephens 1989, Nothnagel et al. 2013)
- Asparagus decline (Yang 1979, Evans et al. 1990)
Monitoring of AV-1 infection in Europe and America

- AV-1 is worldwide distributed
- It is widespread in the regions of production in Germany (infection ~ 100 %)
- The current grown cultivars are highly susceptible to AV-1

<table>
<thead>
<tr>
<th>Asparagus samples</th>
<th>Number</th>
<th>Infection AV-1 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>USA</td>
<td>20</td>
<td>95</td>
</tr>
<tr>
<td>Peru</td>
<td>68</td>
<td>22.1</td>
</tr>
<tr>
<td>Germany</td>
<td>776</td>
<td>100</td>
</tr>
<tr>
<td>Netherlands</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Austria</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Greece</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Spain</td>
<td>5</td>
<td>12.5</td>
</tr>
<tr>
<td>Total</td>
<td>934</td>
<td></td>
</tr>
</tbody>
</table>

Effects of AV-1 on asparagus
Experimental design: material

- Container experiment under greenhouse conditions
- Cultivars: cvs. Eposs, Ravel, Gijnlim
- Virus isolate: AV-1 (DSMZ* No.: PV-0955)
- 20 plants / cultivar were inoculated by viruliferous *M. persicae*
- Infected and control plants were separated

*Deutsche Sammlung von Mikroorganismen und Zellkulturen, Braunschweig, Germany*
Experimental design: timeline

I. Evaluation (90 dpi)
- Shoot number
- Shoot length
- Shoot weight
- Root weight

II. Evaluation (190 dpi)
- Shoot number
- Shoot length
- Shoot weight
- Root weight
- Root development (LemnaTec)
- Brix value (Refractometer)

III. Evaluation (350 dpi)
- Spears VOCs
- Spears weight*
- Spears diameter*
- Spears number*

50 dps: Infection

50-90 dpi

90-190 dpi

190-260 dpi

260 dpi: Re-planting

275-300 dpi

Sowing

Growth

Growth

Storing at 0 °C

Spears harvest

*dps: days post sowing
 dpi: days post infection

* In progress
### Experimental design: measurements

<table>
<thead>
<tr>
<th>Number of shoots</th>
<th>Length of shoots</th>
<th>Weight of shoots</th>
<th>Weight of roots</th>
</tr>
</thead>
</table>

LemnaTec Scanalyser\textsuperscript{PL} = digital plant phenotyping

- Total area of roots (mm\textsuperscript{2})
- Total root length (mm)
- Ratio of root diameter (mm)

Ratio of storage- and fine roots
Experimental design: compounds

Brix value
• Measured by a digital refractometer
• A part of the root and stem was collected
• 100 µl sap were pressed

Volatile organic compound (VOCs)
• Raw plant material
• Headspace solid-phase micro extraction*
• Gas chromatography (GC)
• Mass spectrometry (MS)

* Established by D. Ulrich
Results
Number of shoots

- No significant effects evidenced
- Only Ravel showed 90 dpi significant differences

Different letters show significance by T-test 0.05

n = 20
In tendency the shoots were shorter in the infected plants.
The differences in case of Ravel and Gijnlim were significantly different letters show significance by T-test 0.05.
Weight of shoots (g)

- In cases of infected plants the weight of shoots were less
- In four cases these differences were significant

Different letters show significance by T-test 0.05
Weight of roots (g)

- Significantly reduced root yield for infected plants
- Yield reduction by 190 dpi: Eposs 31 %
  Ravel 33 %
  Gijnlim 59 %

Different letters show significance by T-test 0.05

Control
Infection
n = 20
Significance of brix value in the shoot could only be detected in case of Gijnlim.

The brix value in the root of the infected Ravel and Gijnlim is significantly reduced than in control Ravel and Gijnlim.
Total root area (mm$^2$) and total root length (mm)

- The total root area was less in the infected plants.
- The total root length was less in the infected plants.

Different letters show significance by T-test 0.05
The ratio of fine roots is significantly higher in the infected plants.
The ratio of storage roots was significantly reduced in infected Ravel and Gijnlim.

Different letters show significance by T-test 0.05
White color marks ratio of roots in percent

n = 20

- Eposs
- Ravel
- Gijnlim

- Storage root
- Fine root

Control
Infection
## Volatile compounds (VOCs)

**Peaks:** 121  
**Identified:** 36  
**Showed:** 11

![Graph showing VOC peaks]

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Eposs</th>
<th>Ravel</th>
<th>Gijnlim</th>
<th>Change (%)</th>
<th>Hedonic effect of the compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-hexanol</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>35</td>
<td>+</td>
</tr>
<tr>
<td>ethyl hexanoate</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>35</td>
<td>+</td>
</tr>
<tr>
<td>6-methyl-5-hepten-2-one</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>19</td>
<td>++</td>
</tr>
<tr>
<td>(E)-2-butenal</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>124</td>
<td>-</td>
</tr>
<tr>
<td>nonanal</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>29</td>
<td>-</td>
</tr>
<tr>
<td>benzaldehyde</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>38</td>
<td>++</td>
</tr>
<tr>
<td>b-cyclocitral</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>52</td>
<td>++</td>
</tr>
<tr>
<td>3-octanol</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>119</td>
<td>++</td>
</tr>
<tr>
<td>(E,E)-3,5-octadien-2-one</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>38</td>
<td>++</td>
</tr>
<tr>
<td>benzenacetaldehyde</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>41</td>
<td>+++</td>
</tr>
<tr>
<td>(E)-b-ionon</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>38</td>
<td>+++</td>
</tr>
</tbody>
</table>

- The VOCs changed in the infected plants compared to controls  
- In 10 cases, an increase, and in one case a decrease were observed

Yellow color marks significant differences
Summary

• AV-1 has an impact on both the yield and quality
• Effects on shoot
  ✓ Strong effect on shoot weight (10 – 46 %)
  ✓ Less effect on number and length
• Effects on root
  ✓ Reduction of root weight (31 – 61 %)
  ✓ Decrease of storage root ratio (10 %)
  ✓ Influence on brix value (12 – 32 %)
• 11 VOCs showed strong changes in one direction (10 up / 1 down) for the three cultivars (19 – 124 %)

Outlook
• To verify this results, experiment shall be repeated
• Analysis of non-volatile compounds are in progress
Thank you for your attention!

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