Workshop: Modern landraces – cultivar mixtures in Agriculture

Experiences with cultivar mixtures in Denmark, emphasizing pathogen aspects

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Monoculture

- Is convenient to grow
  Easy to plant and harvest
  Easy to market
  Easy to identify as one variety

- Production optimized

- BUT vulnerable to disease

Race-specific resistance causing directional selection
Diversification strategies for avoiding directional selection for virulence:

Genotype mixtures

- **Variety mixtures** (Mechanical mixtures of varieties)
- **Multilines** (Mechanical mixtures of lines (made by backcrossing))

mainly aiming at airborne pathogens

gene-for-gene interactions

Ex: Barley, wheat, potato
Mechanisms of disease reduction in mixtures

- Greater distance between susceptible plants
- Physical barrier effects of resistant plants
- Induced resistance
- And
- Plant competition
- Interaction among pathogen races
- Modification of the microclimate

Mixture composed of varieties with diff. Res. genes
Multilines and cultivar mixtures are expected to:

- **Delay the epidemic**
  - Ex 1: Powdery mildew of barley
  - Ex 2: Yellow rust of wheat
  - Ex 3: Late blight of potato

- **Stabilize the composition of the pathogen population**
  - Ex 1: Powdery mildew
Barley Multilines:

Accumulated number of powdery mildew colonies per plant in a spring barley multiline M31 and its component lines P-01, P-02, P-07, and P-11.
Observed powdery mildew (relative to p.m. in susc. standard) of 5 barley lines and observed and calculated powdery mildew of the multilines M-31 and M-32
Grain yield increase relative to susc.standard of 5 lines and 2 multilines compared to the calculated yield of the multilines
Observed powdery mildew level as a function of proportion of susceptible plants in 6 Pallas/P11 mixtures and 2 components in pure stands.
The mixing effects as a function of the proportion of susceptible plants in Pallas/P11 mixtures.
Observed powdery mildew reduction in Pallas/P11-mixtures relative to susceptible Pallas in pure stand at three dates

Proportion of resistant plants

<table>
<thead>
<tr>
<th>Date</th>
<th>0.0</th>
<th>0.2</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 June</td>
<td>0.0</td>
<td>16.5</td>
<td>57.0</td>
<td>72.2</td>
<td>81.0</td>
<td>86.1</td>
<td>92.4</td>
</tr>
<tr>
<td>16 June</td>
<td>0.0</td>
<td>25.5</td>
<td>57.7</td>
<td>62.5</td>
<td>79.8</td>
<td>86.5</td>
<td>96.2</td>
</tr>
<tr>
<td>29 June</td>
<td>0.0</td>
<td>42.4</td>
<td>68.6</td>
<td>80.5</td>
<td>83.9</td>
<td>90.7</td>
<td>95.8</td>
</tr>
</tbody>
</table>
Barley mixtures, conclusions

- The powdery mildew reduction: 30 - 80%
- Yield increase: 3-5 %
- The powdery mildew reducing effects of mixtures can be predicted from the resistance levels of the components in pure stands.
The influence of cultural practices on diseases in variety mixtures

Effect of nitrogen: winter wheat and yellow rust

Effect of sowing patterns and plant density: spring wheat and yellow rust
Effects of nitrogen supply and host-diversity on yellow rust

Yellow rust severity ratio estimates for the period from June 10 ($y_1$) to June 26 ($y_2$) ($n = 24$)

<table>
<thead>
<tr>
<th>Crop</th>
<th>N-level</th>
<th>$\log_e(Y_2/y_1)^a$</th>
<th>$Y_2/y_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixture</td>
<td>Low</td>
<td>0.40$^a$</td>
<td>1.5</td>
</tr>
<tr>
<td>Mixture</td>
<td>High</td>
<td>1.65$^b$</td>
<td>5.2</td>
</tr>
<tr>
<td>Boston</td>
<td>Low</td>
<td>2.09$^b$</td>
<td>8.1</td>
</tr>
<tr>
<td>Boston</td>
<td>High</td>
<td>2.28$^b$</td>
<td>9.8</td>
</tr>
</tbody>
</table>

$^a$ Estimates of crop*N-level effects not followed by the same letter were significantly different at $P < 0.05$ (adjusted t-test)
The influence of sowing pattern and density on yellow rust in spring wheat mixture (Amaretto and AC Vista)

H: high density - 730 plants/m²
L: Low density – 350 plants/m²
Row: in rows
Uni: Uniform sowing patterns

1.5 m Nordsten
- Normal row sowing

Mini-air
- Sowing in a two-dimensional pattern
Conclusion: Mixtures - cultural practices

- The high nitrogen level enhanced the epidemic development.

- The yellow rust reducing effect was strongest at the low nitrogen level.

- Lowest yellow rust level at high plant density.

- Lowest yellow rust level in the wheat sown in rows compared to the uniform crop.
Late blight epidemics in potato variety mixtures

Objective:
How efficient are mixtures of potato varieties with different levels of partial resistance in reducing late blight

Two locations – two years:
Four varieties and one mixture
Kuras, Porducnet, Danya, Oleva
Plot size: 24 x 24 m
Data collection: Severity %
Potato mixture
Late blight development in four potato varieties and a mixture

Date

% severity

0 25 50 75 100

18-jul 23-jul 28-jul 02-aug 07-aug 12-aug 17-aug 22-aug

Kuras
Danva
Oleva
Producent
Mixture
Late blight severity (relative AUDPC) in a potato variety mixture and the mean of the 4 component varieties at two sites in two years.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Borris 2001 AUDPC in %</th>
<th>Jyndevad 2001 AUDPC in %</th>
<th>Borris 2002 AUDPC in %</th>
<th>Jyndevad 2002 AUDPC in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean for pure stand varieties</td>
<td>115 a</td>
<td>107 a</td>
<td>103 a</td>
<td>98 a</td>
</tr>
<tr>
<td>Mixture</td>
<td>100 b</td>
<td>100 a</td>
<td>100 a</td>
<td>100 a</td>
</tr>
</tbody>
</table>

\[ p = 0.0038 \]

\[ p = 0.3127 \]

\[ p = 0.4062 \]

\[ p = 0.1688 \]
Potato mixtures, conclusion

- Mixtures composed of partial resistant varieties did not generally reduce late blight.

- Tuber yield of mixture = average of yield of component yield.

- Same for tuber blight

Conclusions from literature: Mixed results on effects, but mixtures composed of varieties with different race-specific resistance genes perform better
Multilines and cultivar mixtures are expected to:

- Stabilize the composition of the pathogen population (selection against unnecessary virulence genes)

- Ex 1: Powdery mildew model experiment
Powdery mildew model experiment
Model experiment:

Frequencies of genotypes with 0 to 6 necessary virulence genes in a barley powdery mildew population grown from spring year 1 to spring year 5.

Spr = spring, Aut = autumn.
Overall conclusions

- Crop diversity provides an ecological approach to sustainable disease management

- The effects vary among host-pathogen combinations and agro-ecosystems
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