Rating Clubroot Resistance

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Background

• A clear, accurate & consistent definition of clubroot resistance is needed to guide breeding efforts & evaluate claims

• Produced set of “clubroot resistance screening guidelines and protocols” for the WCC/RRC
  – General agreement, but questions still need to be answered

• Focus of this talk:
  – Evaluating host reactions
  – Rationale for designations
  – Identifying gaps
Evaluating Host Reactions

- Has proven problematic in the literature
  - Host genotypes are rarely completely immune
  - Wide range of host reactions often observed
General Approach

• Assign disease ratings to individual plants

• Calculate a “disease index” or “index of disease” for group as a whole
  – Number of different rating scales have been proposed (0 to 9; 0 to 4; 0 to 3)
  – Several formulas for calculating ID also developed (fairly similar)
Rating System in Canada

• We adopted a 0-3 scale, based on Kuginuki et al. (1999)
  – Amongst most commonly used in literature
  – In the scales with many categories (0-9), most reactions tended to be grouped into just a few groups
  – Published extensively using this scale
    • Strelkov et al. 2006, 2007; Cao et al. 2007; Xue et al. 2008, etc.
Clubroot Rating Scale

0 = no galling
1 = a few small galls (small galls on <1/3 of roots)
2 = moderate galling (small to medium galls on 1/3 – 2/3 of roots)
3 = severe galling (medium to large galls on > 2/3 of roots)

Based on Kuginuki et al. (1999) as modified by Xue et al. (2008)
Clubroot Rating Scale

Individual scores then used to obtain an Index of Disease for group of plants
Index of Disease (ID)

- Individual scores used to calculate an ID according to formula of Horiuchi & Hori (1980) as modified by Strelkov et al. (2006):

\[
ID(\%) = \frac{\sum (n \times 0 + n \times 1 + n \times 2 + n \times 3)}{N \times 3} \times 100\%
\]

Where: \( n \) is number of plants in a class; \( N \) is total number of plants; and 0, 1, 2 and 3 are the symptom severity classes.
Index of Disease

• Captures range of reactions:
  – 0% (no disease) → 100% (completely susceptible)

• What ID corresponds to resistance?
Resistant vs. Susceptible

• Numerous methods have been used to differentiate resistant vs. susceptible reactions
  – ID ≤ 20% resistant, ≥ 80% susceptible, 20-80% indistinct
  – ID < 50% or < 25% is resistant
  – LSD
  – *Suggested multiple categories (R, MR, MS, S) to reflect range of reactions*
Classification of Host Reactions

• Initial recommendation to Plant Pathology Sub-Committee of WCC/RRC:
  \[ ID < 30\% \text{ of check} = \text{Resistant (R)} \]
  \[ ID \, 30-49\% = \text{Moderately Resistant (MR)} \]
  \[ ID \, 50-69\% = \text{Moderately Susceptible (MS)} \]
  \[ ID \geq 70\% = \text{Susceptible (S)} \]

• Sub-Committee did not approve of MR & MS classifications in absence of yield loss data
Classification of Host Reactions

- In absence of yield loss data, recommended 3 classifications:
  
  \[ \text{ID} < 30\% \text{ of check} = \text{Resistant (R)} \]
  
  \[ \text{ID} 30-69\% = \text{Intermediate (I)} \]
  
  \[ \text{ID} \geq 70\% = \text{Susceptible (S)} \]

Clubroot trials will be accepted when ID of susceptible check > 60\%
Effect of Clubroot on Canola Yields

- Pageau et al. (2006):
  - Severe infection resulted in yield losses > 80%

- Wallenhammar et al. (1999):
  - Infestations of 91% caused 50% yield loss, infestations of less than 20% caused 10% loss
  - Referred to incidence, not severity!
Clubroot and Yield Loss

• Need to establish the yield loss-clubroot severity relationship for canola in Canadian context
  – Part of the “vision”
  – Pioneer Hi-Bred providing lines with differential reactions

• Provide guidance when evaluating canola lines for resistance claims, more informative for growers and industry
Conclusion

- Well-developed system for assessing clubroot reactions
- Less clarity on what constitutes resistance, especially for variety evaluation
- Require a yield loss model for canola