Comparative epidemiology of late blight and early blight on potato cultivars

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Overview of the experiment

Late blight (LB), caused by *Phytophthora infestans*, and early blight (EB), caused by *Alternaria solani*, are the most destructive diseases in potatoes globally and in Denmark. Although the onset of their epidemic might differ, they are both present on potato cultivars in most growing seasons. Thus, it is relevant to assess potato cultivars for their resistance to these major diseases. Accordingly, we evaluated epidemics of LB and EB on some relatively new cultivars (Ardeche, Avito, Fyone, Jacky, Nofy, Sarion, Skawa, Thor and Ydun) and one old potato cultivar (Kuras) in Denmark. We performed field experiments separately for LB and EB at AU Flakkebjerg in 2021. The two experiments were adjacent to each other to allow for similar growth and weather conditions for the disease development. The potatoes were planted on 14 May 2021. The EB trial was inoculated on 22 June 2021 by placing 110 g of autoclaved barley grains infested with *A. solani* between the rows. Spreader rows were artificially inoculated to ensure an even inoculum distribution in the LB trial. Disease severity was assessed once or twice per week as the percentage of leaf area affected, depending on the disease progression.

Data analysis

The diseases severity data were fitted to the Richards growth model (Richards, 1959) (Equation 1), where Y is the severity at a time (t), Yasm is the upper asymptote on the y-axis, k is the growth rate, Tip is the point of inflection on the x-axis, v is a parameter that partly determines the inflection point and e represent exponent. The model fitting was implemented with the Levenberg-Marquardt non-linear least squares algorithm ("nlsLM" function) (Timur et al., 2016) in R language and environment for programming and statistical computing (hereafter R) (R Core Team, 2020). The days after 1 June were used as the time variable (x-axis). The weighted mean absolute rate (WMAR) (Equation 2) was calculated to compare the epidemic rate of the diseases on the cultivars. WMAR is a better metric for comparing curves with different shapes (m) and upper asymptotes. The shape parameter (m) was calculated with Equation 3. The relative area under the disease progress curve (rAUDPC) was calculated with Equation 4, where y_i is the disease severity at the i^{th} assessment, t_i is the date/time at the i^{th} assessment, n is the total number of assessments, t_n-t_o is the epidemic duration and Dmax is the maximum potential disease severity (100):

$$Y = \frac{Yasm}{\left[1+ve^{-k(t-Tip)}\right]^{1/v}} \quad (1)$$

$$WMAR = \frac{k}{2m+2} \times Yasm \quad (2)$$

$$m = v + 1 \quad (3)$$

$$rAUDPC = \frac{\sum_{i=1}^{n} \frac{(y_i+y_{i+1})}{2} \times (t_{i+1}-t_i)}{(t_n-t_0)\times Dmax} \quad (4)$$

Results

Disease progress curves

The development of LB and EB on the cultivars is shown in Figure 1.

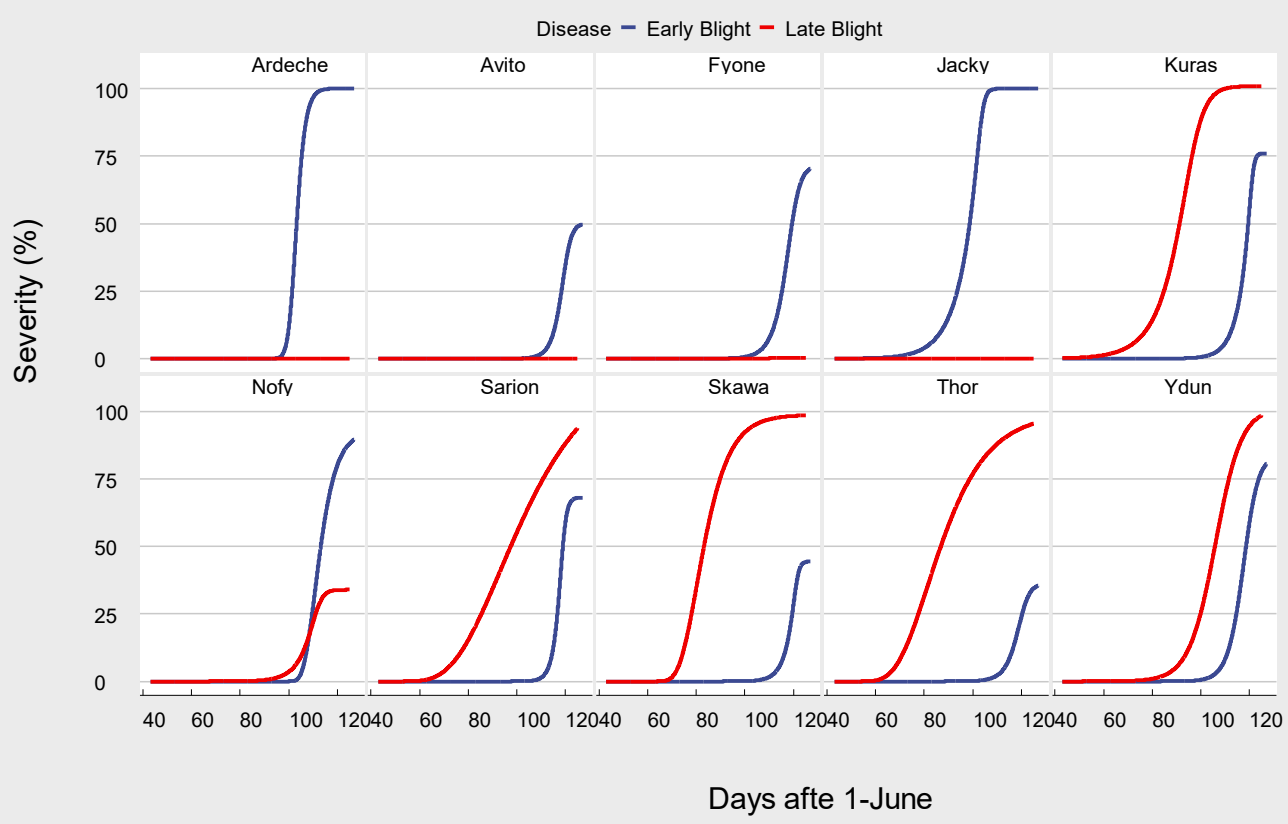

Figure 1. Development of early blight (*Alternaria solani*) and late blight (*Phytophthora infestans*) on different potato cultivars.

Comparing the cultivars for different epidemiological parameters

We compared the cultivars for different epidemiological parameters for assessing their resistance to late blight and early blight (Figure 2). These parameters are a different aspect of the disease progress curve and thus offer a different understanding of the disease development. WMAR is a reflection of the epidemic rate, rAUDPC summarises the diseased area over time relative to the Dmax, Yasm is a measure of the maximum severity and T1 is when 1% severity occurred and thus it indicates when the epidemic began to rise quickly.

The results showed that, except for the cultivars that restricted LB below 1% (Avito, Ardeche, Jacky, and Fyone) or 35% severity (Nofy), the Yasm of LB on the remaining cultivars was >90% (Figure 2). The cultivars with low Yasm are generally more resistant to LB, and thus this observed low Yasm was not surprising. The Yasm of EB for most cultivars ranged between 35% and 90%, with only a few cultivars reaching 100% severity. The rAUDPC values also showed that LB was more severe than EB on most cultivars. The exceptions were the cultivars Avito, Ardeche, Jacky and Fyone, on which EB was higher than LB for rAUDPC (Figure 2).

The results of T1 of LB were markedly shorter than EB for all cultivars but Nofy (Figure 2). In contrast to the other parameters, WMAR was higher for EB than LB on most cultivars. This suggests that once EB reaches 1% on cultivars, its progress can occur faster or similar to LB on a cultivar. However, the general high epidemic profile of LB might be due to the markedly short T1 as this epidemiological parameter marks the beginning of a critical stage in the epidemic. This is also confirmed by the fact that the onset of LB and EB on the cultivars was either similar or longer for LB in comparison with EB (data not shown).

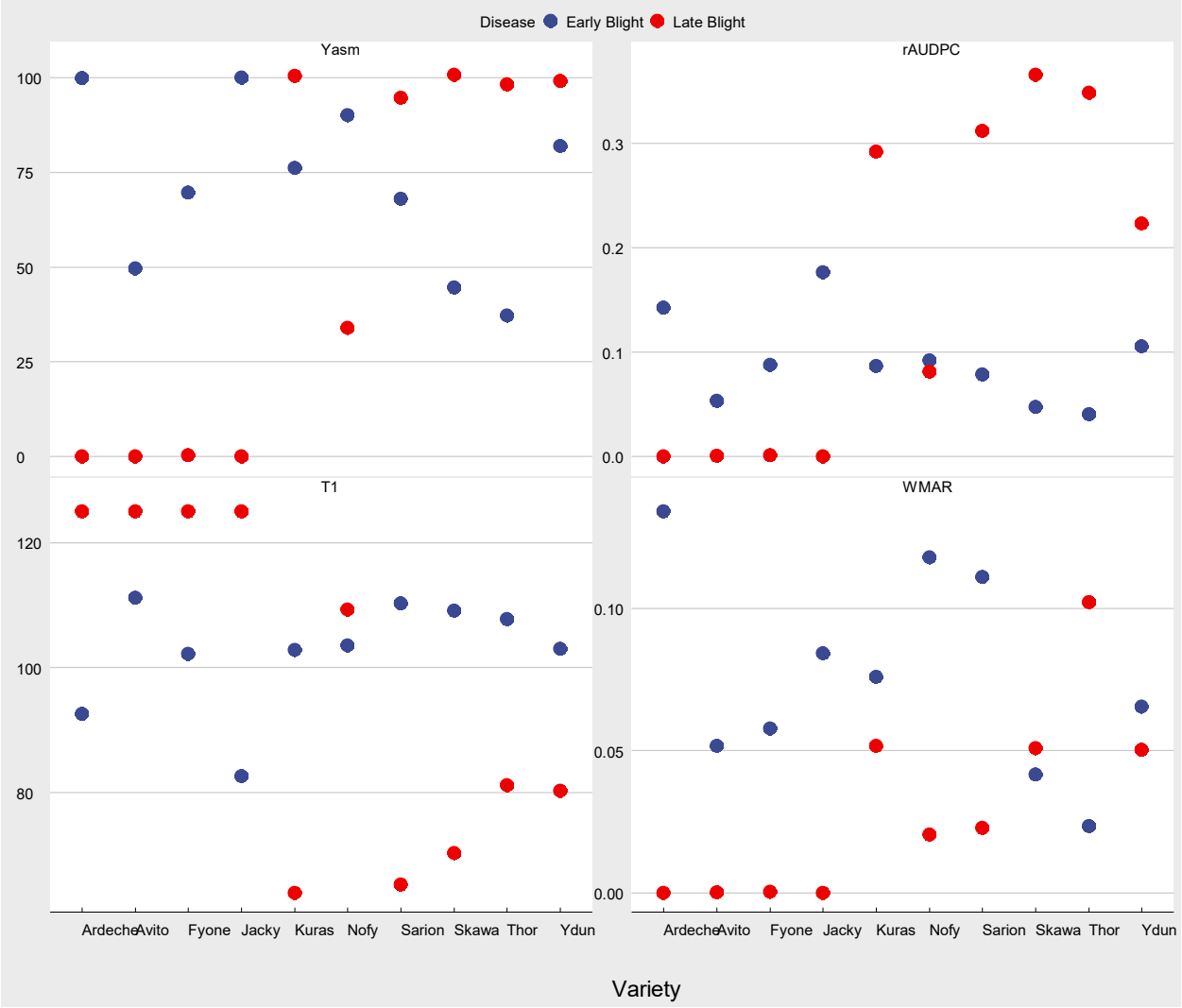

Figure 2. Comparisons of different epidemiological parameters (upper asymptote (Yasm), the relative area under the disease progress curve (rAUDPC), the time taken to reach 1% disease severity (T1) and the weighted mean absolute rate (WMAR)) for assessing the development of late blight and early blight on potato cultivars. For cultivars that did not reach 1% severity, their T1 was expressed as days elapsed from 1 June to the last assessment.

Concluding remarks

This study results in three key conclusions.

- The very resistant LB cultivars such as Avito, Ardeche, Fyone and Jacky are susceptible to EB under the prevailing conditions in Denmark. This is unsurprising because most breeding efforts target LB and not EB. Future efforts must include EB in resistant breeding as EB epidemics are becoming increasingly important under Danish conditions.
- Cultivars such as Skawa and Thor appear to have a good resistance to EB, but are very susceptible to LB. Our previous screenings of cultivar resistance in 2019 and 2020 also confirmed the good resistance of Skawa and Thor to EB.

- The major difference between EB and LB is the onset of their epidemic phase (T1) as EB can develop faster than LB.

References

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Richards, F. J. (1959). A Flexible Growth Function for Empirical Use. Journal of Experimental Botany 10: 290-300.

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