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WURBlight: an experimental decision support module linking fungicide dosage to late blight resistance

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Introduction

In the Netherlands, a highly aggressive, genotypically diverse and sexually reproducing population of *Phytophthora infestans* has displaced the old, clonally reproducing, population during the 1980's and early 1990's (Drenth *et al.*, 1993). This event was one of the factors responsible for ending a period, during the 1970's, in which potato late blight appeared to be under control (Zwankhuizen and Zadoks, 2002). At present, the new *P. infestans* population is more difficult to control than in the past, requiring accurately timed and frequent fungicide applications amounting to 10 – 18 sprays per growing season (Schepers, 2002). In contrast, a restrictive government policy on the use of pesticides and an increasing public concern regarding food safety and the environment call for drastic reductions of the chemical inputs in agriculture. As a result, potato late blight has become the most serious constraint to sustainable potato production in the Netherlands.

One way to reduce the fungicide input against potato late blight is to better exploit the possibilities of partial resistance in potato cultivars. In a four-year project, started in 2002, options for reducing the fungicide input on partially resistant potato cultivars will be explored. At the start, three options were available:

PPO-Special Report no.9 (2003), 31-38

Increase the spray interval on more resistant cultivars using recommended dose rates.

Reduce the dose rate on more resistant cultivars using spray intervals as recommended for susceptible cultivars.

Reduce the dose rate and increase the interval on more resistant cultivars.

Based on the hypothesis that (higher levels of) partial resistance can be supplemented with (reduced dose rates of) fungicide to provide an adequate and reliable level of protection against *P. infestans*, option two was selected for exploration.

Materials and Methods

Four field experiments were carried out. Base line research was done at Lelystad and Wageningen in two field experiments with 30 commonly grown cultivars. Four components of resistance (Infection Efficiency [IE], Latent Period [LP], Lesion Growth Rate [LGR], and Sporulation Intensity [SI]) were measured for each cultivar at the Wageningen site. A reduced dose rateexperiment was carried out at Lelystad where all 30 cultivars were treated with Shirlan (a.i. fluazinam, 500g/L) at each of 6 dose rates (0, 0.08, 0.16, 0.24, 0.32 and 0.4 L Shirlan/ha). Timing of the spray applications was provided by the DSS PLANT-Plus. Spreader rows surrounding the replicate blocks were inoculated on 24 June with a mixture of thirteen current *P. infestans* isolates. At several occasions prior to inoculation, components of resistance, as mentioned above, were also determined in this experiment for 5 cultivars and 6 Shirlan dose rates.

Table 1. Fungicide dose rates recommended by WUR-Blight in two field experiments aimed at evaluating decision rules linking fungicide dose rate and cultivar resistance.

Lelystad (ware potatoes)			Valthermond (starch potatoes)		
Cultivar	Resistance rating[1]	Shirlan Dose rate	Cultivar	Resistance rating[1]	Shirlan Dose rate
Bintje	3	0.4 l/ha	Bintje	3	0.4 l/ha
Santé	4.5	0.32 l/ha	Starga	5.5	0.32 l/ha
Agria	5.5	0.24 l/ha	Karakter	6	0.24 l/ha
Remarka	6.5	0.16 l/ha	Seresta	7	0.16 l/ha
Aziza	7.5	0.08 l/ha	Karnico	8	0.08 l/ha

[1]: Foliar resistance rating according to the Dutch National Variety List.

Performance of a first set of experimental decision rules (described below) linking the level of cultivar resistance to a fungicide dose rate was evaluated in field experiments in Lelystad and Valthermond. Both field experiments included 5 cultivars and were depending on natural infection (Table 1). WUR-Blight was used for advice on timing and dose rate of fungicide applications. The main purpose of WUR-Blight is to develop a (preferably independent) decision support module advising on the dose rate of fungicide applications based on cultivar resistance and crop characteristics. Timing of spray applications is not a research priority.

Decision rules: In this first year, dose rates advised by WUR-Blight were fixed per cultivar based on their resistance rating in the Dutch National Variety List (Table 1). The first spray application was applied at 90% emergence. Follows up applications were timed using SIMCAST decision rules developed for susceptible cultivars (Grünwald, et al., 2002) incorporated in WUR-Blight. Historical weather data (measured on site at 1.5m above ground) and actual late blight management (recommended versus implemented sprays) were used as input. Spray recommendations were issued when the threshold for Blight Units or Fungicide Units was reached. The range of available fungicides was limited to Shirlan to achieve a purely preventive fungicide-based control strategy. Figure 1 shows a schematic representation of the modular set up of WUR-Blight. WUR-Blight was implemented using Visual Fortran.

Decision rules are evaluated annually using results from all four field experiments and will be subsequently modified and improved.

Data analysis: Sigmoid curves were fitted to severity observations for the period 24 June (inoculation) – 19 July when unprotected susceptible cultivars were affected up to 90% severity. From the fitted curves, three parameters were estimated: the apparent infection rate (slope), the number of days between inoculation and 10% severity (delay) and the standardised area under the disease progress curve (stAUDPC).

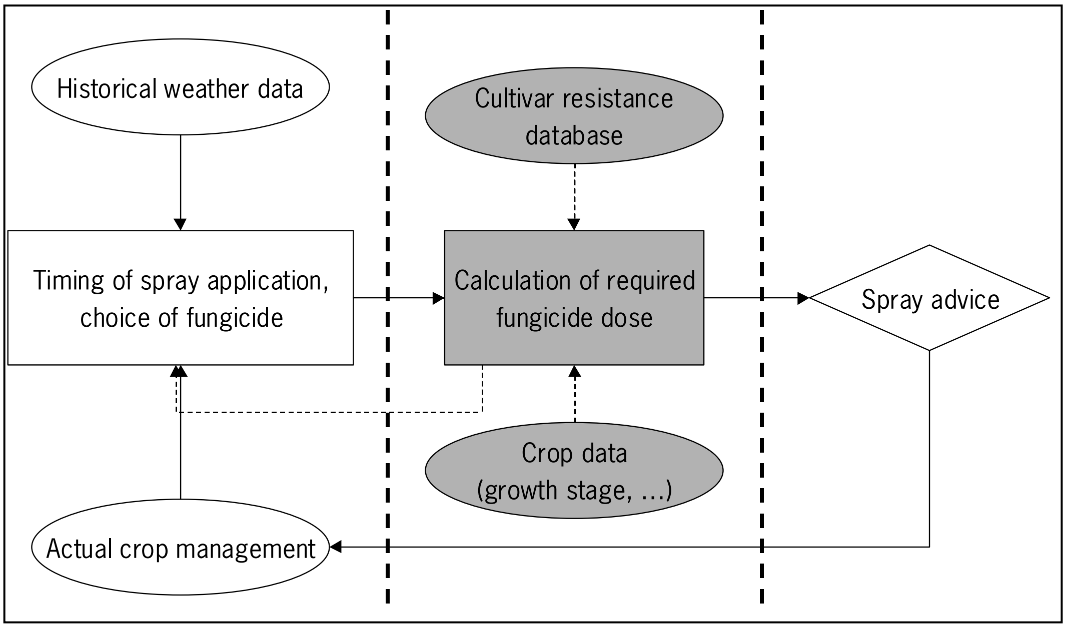

Figure 1. Schematic representation of the modular set up of WUR-Blight. Purpose of WUR-Blight is to link the level of cultivar resistance to a (reduced) fungicide dose rate, primarily by developing relations between the components in gray.

Results

Components of resistance: Infection efficiency (IE) was increasingly reduced with increasing Shirlan dose rates. Shirlan effects on other components of resistance were not detected. Figure 2 illustrates the effects of a range of Shirlan dose rates on IE as measured for cultivars Desiree and Santé.

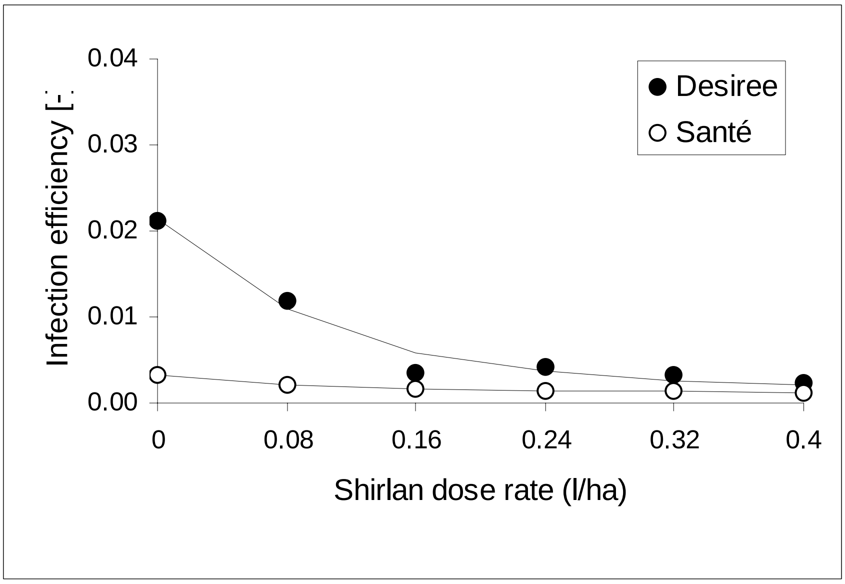

Figure 2. Effect of a range of Shirlan dose rates on the infection efficiency of *P. infestans* sporangia on cultivars Desiree and Santé.

Reduced dose rate experiment: Spreader rows were inoculated on 24 June. During the first week of July, a spray was recommended which could not be carried out for four days due to adverse weather conditions. Consequently, many lesions were found on 9 June. Lesion counts revealed cultivar effects but no dose rate effects on the average number of lesions indicating that the crop had been unprotected during this critical period. From this point on, spray recommendations were carried out according to DSS recommendation resulting in a reduction of the epidemic growth rate. This is illustrated by a Shirlan dose rate effect on the apparent infection rate (slope), the delay and the stAUDPC (illustrated for 9 cultivars in Figure 3).

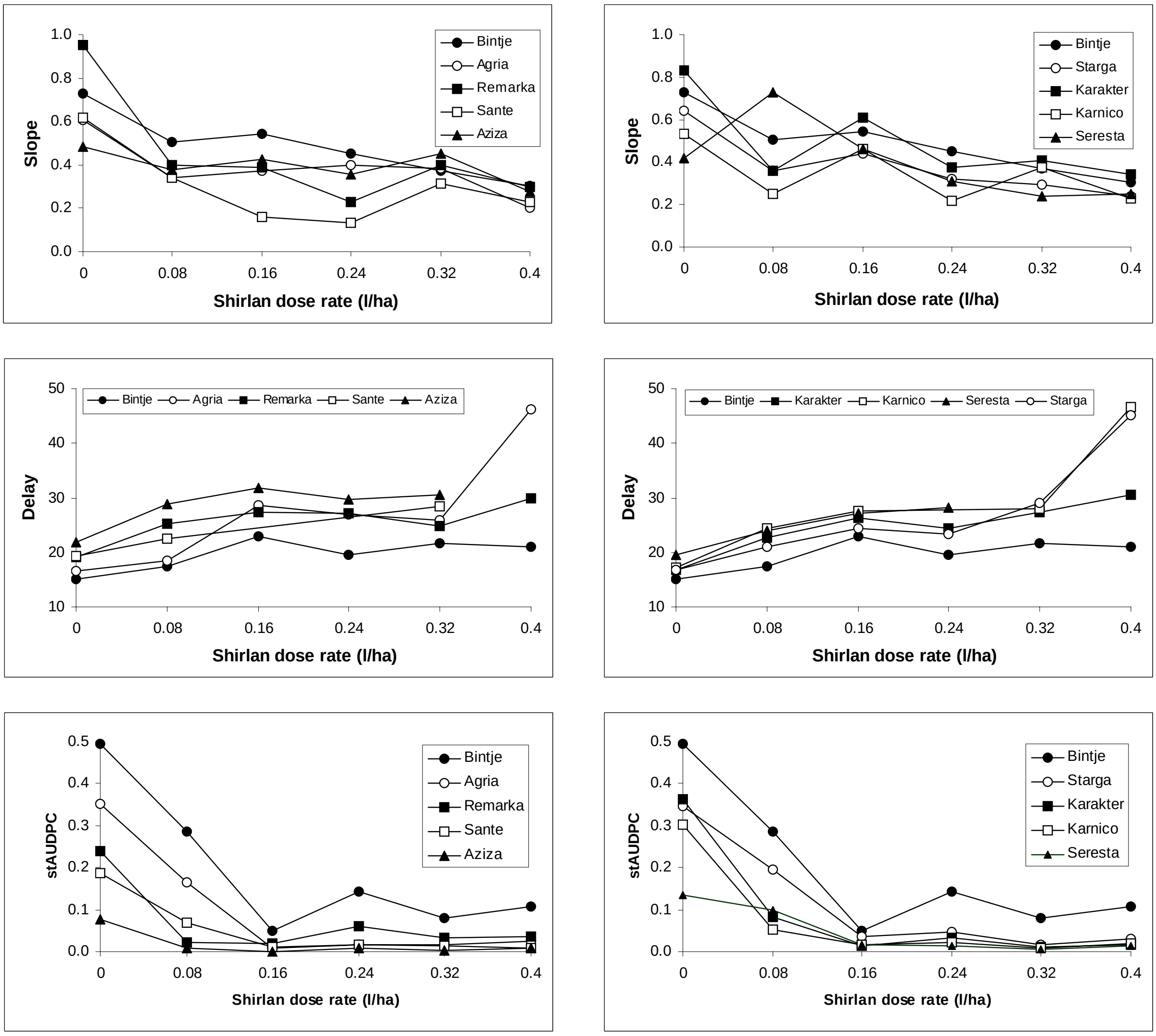

Figure 3. Effect of a range of Shirlan dose rates on (regression) parameters describing the potato late blight epidemic for 9 selected cultivars.

The epidemic growth rate (slope) is generally decreasing with increasing Shirlan dose rates, whereas a delay in the onset of the epidemic is positively associated with increasing Shirlan dose rates. The combined effect on both regression parameters explains the significant decrease in stAUDPC with increasing Shirlan dose rates (Figure 3).

Evaluation experiments: Two evaluation experiments were carried out: one in Lelystad (ware potatoes) and one in Valthermond (starch potatoes). Cultivars were sprayed using the WUR-Blight dose rates given in Table 1 while timing was provided by the SIMCAST decision rules incorporated in WUR-Blight.

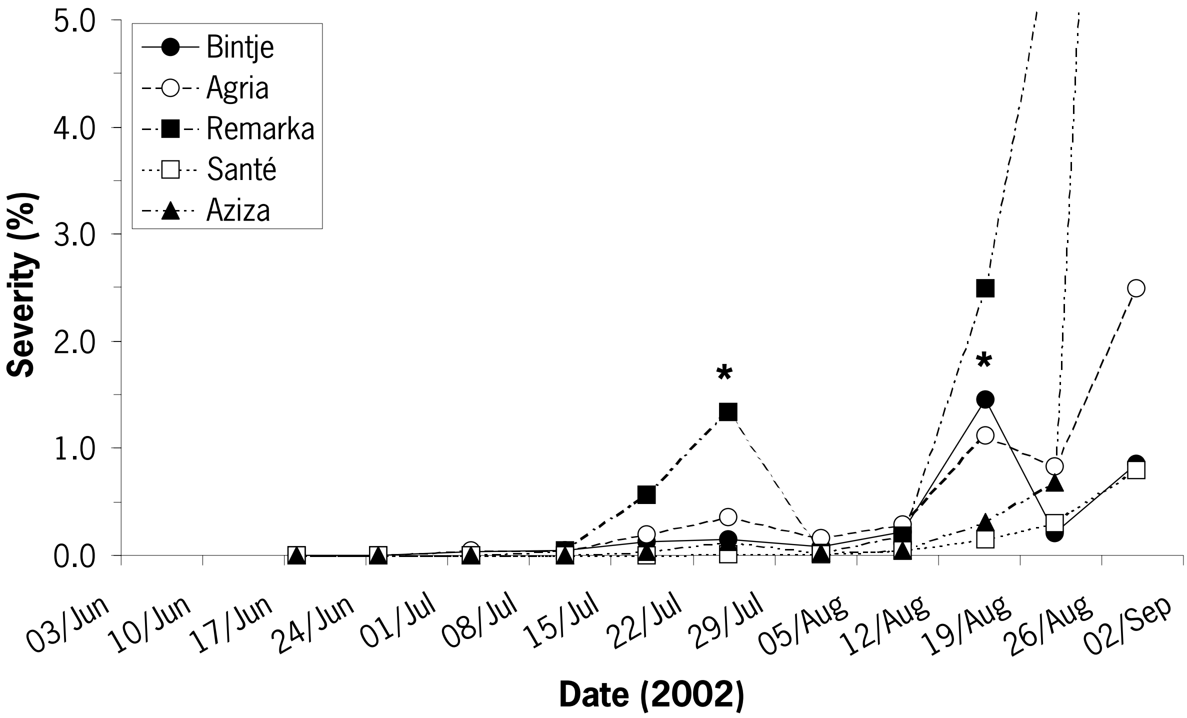

Figure 4. Disease progress curves of 5 potato cultivars representing a range from susceptible to resistant against *P. infestans*. Cultivars were sprayed with reduced dose rates of Shirlan according to Table 1. Single plots of Remarka (24 July) and Agria and Bintje (19 August) were prematurely desiccated (*).

Disease pressure in the Valthermond experiment remained low during the entire growing season and hardly any potato late blight was detected in any of the cultivars. Critical evaluation of the dose rate decision rules based on this experiment was thus rendered futile.

Disease pressure in the Lelystad experiment was high resulting in early detection of potato late blight in the experiment. Disease progress curves are given in Figure 4. Plots were sprayed 11 times before they were desiccated on 29 August. 1 plot of Remarka (24 July) and one plot of both Agria and Bintje (16 August) had to be desiccated prematurely, accounting for a reduction of the average disease severity per cultivar in Figure 4. The total fungicide input over the season per cultivar is equivalent to 4.4 l Shirlan/ha for Bintje, 3.52 l/ha for Santé, 2.64 l/ha for Agria, 1.74 l/ha for Remarka and 0.88 l/ha for Aziza. However, blight control proved not satisfactory for all cultivars tested. During the first week of July, disease pressure was very high due to bad weather and nearby inoculum sources, resulting in a general increase of disease severity for all cultivars but especially for Remarka. Following this event, one severely diseased Remarka plot had to be prematurely desiccated. Similar high disease pressure during the first week of August again caused a sharp increase of disease severity for Remarka, Bintje and Agria. Santé and Aziza plots only got severely infected in late August when maturation set in.

Discussion

Multiple field- and laboratory experiments were carried out to explore possibilities of reducing fungicide dose rates applied to control potato late blight on more resistant cultivars. This approach was adopted to avoid potential problems caused by fungicide wear off and re-distribution. Shirlan was selected because it is the most widely used protectant on the Dutch market. The final goal of the project is to be able to reliably link cultivar specific disease resistance, expressed in each of 5 components of resistance and stored in a database, to a minimal fungicide dose rate providing adequate protection against potato late blight. Considering the preventive nature of most control strategies, infection efficiency (IE) is probably the most important of the five components of resistance largely defining the possibilities for application of reduced dose rates. Since partial resistance, by definition, will not provide plant immunity, disease pressure and possible effects of physiological ageing on the level of partial resistance will also have to be taken into account in future versions of WUR-Blight.

Spray recommendations issued for the reduced dose rate experiment in Lelystad during the first week of July could not be carried out due to bad weather. The crop was thus left virtually unprotected during this critical period. Multiple infections were found shortly after. Nevertheless, epidemic progress was increasingly reduced with increasing Shirlan dose rates following this event and differences between cultivars were evident (Figure 3). Future experiments should however include the possibility of curative measures.

The Lelystad evaluation experiment clearly shows that it is possible to adequately protect more resistant cultivars using reduced fungicide dose rates (Figure 4). Disease pressure in the experiment was high as illustrated by the disease progress curve for Bintje, which was sprayed using the recommended dose rate. However, Aziza and Santé, sprayed with dose rates of 0.08 and 0.32 l/ha, performed well except for the last part of the growing season when maturation set in. Agria and especially Remarka were under-protected. Apparently, resistance ratings from the Dutch national variety list are ill suited as a base for recommending reduced dose rates on more resistant cultivars. A more solid base for dose rate recommendations is urgently needed. A data base comprising information on all 5 resistance components and field performance of potato cultivars, as is being created based on the Wageningen base line experiments, will very likely fulfil this need.

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