

## Fungicide dose rates & cultivar resistance, results of five years of field experiments in the Netherlands

HARRO SPITS<sup>1</sup>, BERT EVENHUIS<sup>1,2</sup> & HUUB SCHEPERS<sup>1</sup>

<sup>1</sup> Applied Plant Research, P.O. Box 430, 8200 AK Lelystad, the Netherlands

<sup>2</sup> Plant Research International, P.O.Box 16, 6700 AA Wageningen, the Netherlands.

### Introduction

In 2003, the Dutch Umbrella Plan Phytophthora was launched. Within the Umbrella Plan, the Dutch grower organisation LTO, potato industry, potato trade and Wageningen-UR work together to achieve the common goal of 75% reduction of the environmental burden due to potato late blight control within 10 years.

One of the possibilities to reduce the fungicide input in a preventive control strategy is to use reduced dose rates of protectant fungicides on more resistant potato cultivars (Fry, 1975; Clayton & Shattock, 1995; Nærstad, 2002; Kessel *et al.*, 2004). This option was explored in a series of field experiments 2002 – 2006 in which several potato cultivars were protected with a range of Shirlan dose rates under high disease pressure. Protection of foliage as well as the protection of tubers were included in these experiments.

The aim of the project was to assess the possibilities of dose rate reduction based upon the resistance level of the cultivar. Calculated (minimum) dose rate for several cultivars under high disease pressure are presented.

### Materials and Methods

#### *Foliar blight experiments*

The possibilities to use reduced dose rates of protectant fungicides on more resistant potato cultivars was explored in the years 2002-2006. During 2002 -2004 experiments were set up to explore these possibilities for the protection of foliage (growth). 30 (2002) or 34 (2003 & 2004) varieties were protected with a range of Shirlan (fluazinam 500 g/l) dose rates (0%, 20%, 40%, 60%, 80%, 100% of the recommended (label) dose rate of 0.4 l/ha) under high disease pressure. Timing of the spray applications was based on PLANT-Plus recommendations except for the first three sprays which were applied at a weekly interval. Spreader rows (cv Nicola) within the field experiments were artificially inoculated with a mixture of 15 current *P. infestans* isolates. The isolates used were a random sample of isolates gathered during a survey in 2000 throughout the Netherlands. It is assumed that these 15 isolates are representative for the Dutch *P. infestans* population at the time.

Percentage infected foliage was assessed twice a week, from inoculation until haulm kill. Severity data on the epidemics occurring in 2002 and 2004 were analysed. The weather in 2003 was hot and dry resulting in non-representative low-level epidemic.

### *Tuber blight experiments*

In 2005-2006 the experiments were setup to determine the effect of reduced dose rate of Shirlan on tuber protection. 14 varieties were protected with a range of Shirlan dose rates (0%, 20%, 40%, 60%, 80%, 100% of the recommended (label) dose rate of 0.4 l/ha) under high disease pressure. Spraying time was based on disease pressure and the development of the epidemic except for the first sprays with Curzate M (mancozeb 68% + 4.5% cymoxanil) 2.5 kg/ha. which were applied at a weekly interval. Spreader rows (cv Nicola) within the field experiments were artificially inoculated with a mixture of 15 current *P. infestans* isolates. During the epidemic percentage infected foliage was assessed twice a week. Artificial rain (2005, 20 mm and in 2006 10 mm) was applied one day before desiccation of the foliage with Reglone (diquat dibromide 200 g/l).

Three weeks after desiccating the foliage the tubers were harvested (6 m<sup>2</sup>/plot). Directly and three weeks after harvest percentage blighted tubers were assessed.

### **Analysis**

The relative area under the disease progress curve (RAUDPC) was calculated based upon disease severity ratings. Disease parameters were calculated for each combination of variety and fluazinam dose rate.

Exponential curves (Equation 1) were fitted for each cultivar to establish the effect of dose rate on RAUDPC.

$$Y_v = A_v + B_v R_d^X \quad (1)$$

$Y_v$  = the RAUDPC of a given variety (v) at a given dose rate of fluazinam (d)

$X_d$  = fluazinam dose rate

$A_v$ ,  $B_v$  and  $R_v$  are parameters of the fitted exponential curve of disease severity of the variety tested under different fungicide dose rates.

The effective dose rate of shirlan was calculated by comparing the exponential curves fitted based on RAUDPC at different dose rates of a given variety to the fitted exponential curve of the reference variety Bintje. Fitted curves were used to establish the effective dose rate of shirlan (Equation 2).

$$Y_{ref} = A_v + B_v R_v^{X_v} \quad (2)$$

$Y_{ref}$  is the RAUDPC of the reference variety Bintje sprayed at a dose rate of 0.4 l/ha-1

$X_v$  = effective fluazinam dose rate of variety tested

$A_v$ ,  $B_v$  and  $R_v$  are parameters of the fitted exponential curve of disease severity of the variety tested under different fungicide dose rates determined using Equation 1.

To estimate the effect of dose rate reduction on tuber blight double exponential curves were fitted (Equation 3).

$$Y_{vt} = B*(R^X) + C*(S^X) \quad (3)$$

$Y_{vt}$  = percentage tuberblight at dose rate X

B, C, R and S are regression parameters; in which  $0 < R < S < 1$  and B+C represents percentage tuber blight without spraying

X = dose rate

To estimate the minimal dose rate to protect tubers, tuber blight incidence of Bintje sprayed at 0.4 l/ha was used as a reference in 2006. As a reference in 2005 a fixed value of 4 % was chosen since tuber blight incidence of Bintje was too high.

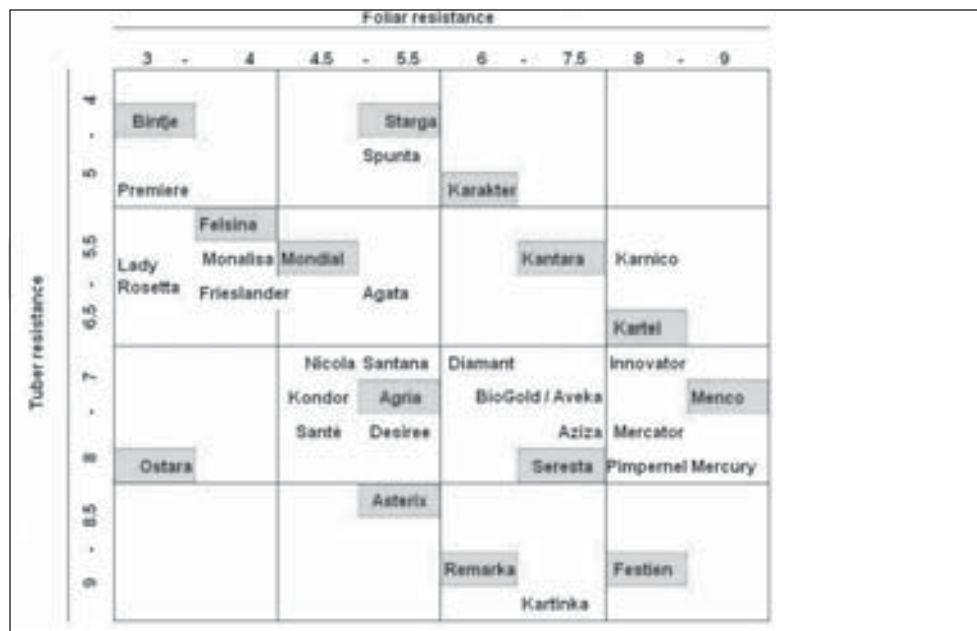


Figure 1. Potato varieties (with resistance level) used in the experiments. Varieties in green bars are also part of the tuber experiments.

Based on calculated dose rates varieties were rated in classes 1 to 4 for the possibility of dose rate reduction. Each variety was classified for foliar blight and tuber blight, separately.

#### Statistics

The experiments were layed out as a split plot design. Dose rate treatments were allotted to the split stratum. Cultivars were randomized within the first stratum. The experiments consisted of three replicates each year. Spreader rows of cultivar Niocla were planted adjacent to each plot. Statistical analysis was performed using Genstat 8 (Payne *et al.*, 2002). Least significant differences were calculated at a significance level of  $\alpha=0.05$ .

Multiple regression was performed to fitt curves to assess disease progress and to establish the effect of dose rate applied on disease progress parameters.

#### Results and discussion

In 2002 weather was very favourable for late bight and the epidemic developed rapidly.

As mentioned before the weather in 2003 was very hot en dry and epidemic did not develop very well. In 2004 the development of the epidemic was sufficient. Weather conditions were favorable for late blight in the second part of the season both in 2005 and 2006. Regular and heavy rainfall during the month of August in combination with the late blight epidemic ensured wash off of sporangia. Therefore disease pressure for tuber blight was high. A dose response effect of Shirlan on leaf blight was shown especially in 2004. Although it was more pronounced in varieties with a low level of resistance (cv. Bintje) compared to varieties with a higher level of resistance (Figure 2).

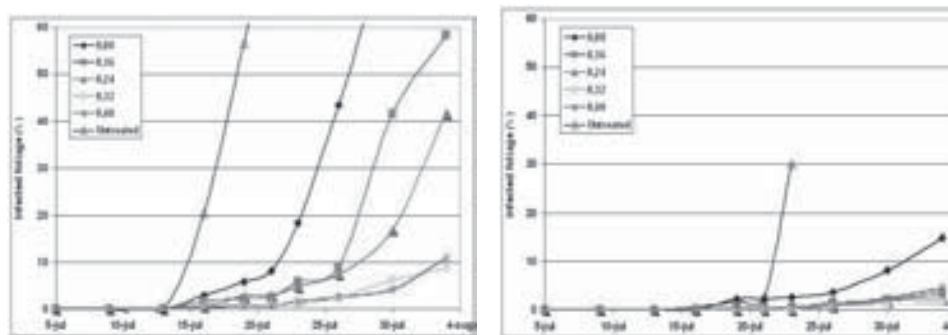


Figure 2. Dose response curves of fluazinam on the late blight susceptible cultivar Bintje (left) and the resistant cultivar Aziza (right).

Based on the dose response curves a suitable dose rate of fluazinam was calculated for each variety. In general potato varieties with a high level of resistance are classified in class 1 and varieties with a low level of resistance in class 4. However there are some varieties that differ from this statement. These varieties are Kantara (7) in class 1 and Kondor (4.5) in class 2. The varieties Kantara and Kondor have a relatively low level of resistance, according to the national list, compared to the class where they have been classified, according to our experiments. Erosion of late blight resistance occurs. The new introduced variety Biogold was rated a 9 for leaf blight resistance. However after introduction in agricultural practice compatible *P. infestans* strains were found. The leaf resistance rating was therefore adjusted to 7 for this variety. This illustrates the necessity of constant monitoring the resistance to late blight of cultivars. Resistance testing with modern isolates is therefore required. Re-evaluation of possibilities for dose rate reduction should be considered, regularly.

The experiments were conducted under high disease pressure. To calculate the acceptable dose rate for each variety, the efficacy of 0.4 l/ha Shirlan sprayed on Bintje was taken as a reference. In the Netherlands it is common practice that 0.3 l/ha of Shirlan is sprayed on Bintje and other varieties. So in practice (with low(er)) disease pressure even lower dose rates can be used without a large increase of the infection risk. This is also presented in Table 1. However, it is very important to spray before a critical period. Decision Support Systems can be very useful to determine the timing of the spray application. The possibility for using the level of cultivar resistance is illustrated in Figure 2.

**Table 1.** Dose rate classes for spray application of Shirlan calculated for 35 Dutch potato varieties.

| Class 1: 0.1    | Class 2: 0.2 (a) | Class 3: 0.3 (a) | Class 4: 0.4 (a)  |
|-----------------|------------------|------------------|-------------------|
| Aziza (7.5) (b) | Diamant (6)      | Felsina (3.5)    | Agata (4)         |
| Biogold (7)     | Kondor (4.5)     | Agria (5.5)      | Asterix (5)       |
| Festien (8)     | Karnico (8)      | Karakter (6)     | Bintje (3)        |
| Innovator (8)   | Katinka (6.5)    | Santé (4.5)      | Frieslander (3.5) |
| Kantara (7)     | Seresta (7)      | Premiere (2.5)   | Monalisa (4)      |
| Kartel (8)      | Aveka (7)        | Santana (5)      | Mondial (4.5)     |
| Menco (9)       | Pimpernel (8)    | Starga (5.5)     | Nicola (4.5)      |
| Mercator (8)    |                  | Ostara (3.5)     | Spunta (5)        |
| Mercury (9)     |                  | Remarka (6.5)    | Lady Rosetta (3)  |
|                 |                  |                  | Desiree (5)       |

(a) At low disease pressure, dose rate can be decreased with maximum of 0.1 l/ha on top of corresponding reduction in the class of the variety.

(b) Between brackets the resistance level according to the national list 2007 is given (Anonymus, 2007)



*Figure 2. Difference in level of infection in Biogold (7) and Agria (5.5), sprayed with the same dose rate of fluazinam.*

Shirlan dose rate reduction for each variety separately, were determined in experiments where development of foliage was present and tuber protection was no issue (first half of the growing season).

So to determine if these calculated reduced dose rates are adequate to control late blight in the second half of the growing season when tuber protection is important experiments were carried out then. Another argument to conduct experiments at the end of the season is that the foliar resistance does not correspond with the tuber resistance. So if resistance to tuber blight, is significantly lower than to leaf blight, continuation of spraying reduced dose rates in the latter part of the season increases the risks for tuber infection.

Based on the experiments a Shirlan dose rate for adequate tuber protection was calculated for each variety, separately. Most of the varieties were classified in the same class for foliar and tuber protection. However, for some varieties with a relative low resistance to tuber blight the possibility to decrease the dose rate of fluazinam in the second half of the season is limited or not present. Some varieties allow dose rate reduction to protect the foliage, but reducing the dose rate for tuber protection is not possible. These varieties are Felsina, Kantara, Karakter, Ostara and Starga. Lowering the dose rate during the second half the season results in a higher level of tuber blight risk for these varieties.

**Table 2.** Dose rate classes of Shirlan for sufficient tuber protection of each variety.

| Class 1: 0.1     | Class 2: 0.2 (a) | Class 3: 0.3 (a)  | Class 4: 0.4 (a)    |
|------------------|------------------|-------------------|---------------------|
| Festien (8 / 9)  | Seresta (7 / 8)  | Agria (5.5 / 7.5) | Asterix (5 / 8.5)   |
| Kartel (8 / 6.5) |                  | Remarka (6.5 / 9) | Bintje (3 / 4.5)    |
| Menco (9 / 7.5)  |                  |                   | Mondial (4.5 / 6)   |
|                  |                  |                   | Felsina (3.5 / 5.5) |
|                  |                  |                   | Kantara (7 / 6)     |
|                  |                  |                   | Karakter (7 / 5)    |
|                  |                  |                   | Ostara (3.5 / 8)    |
|                  |                  |                   | Starga (5.5 / 4.5)  |

(a) At a low disease pressure, dose rate can be decreased with a maximum 25%

(b) Resistance ratings for **foliage** / tuber based on the National list (Anonymus 2007).

### General conclusions

- Application of Shirlan in reduced dose rates is feasible on more resistant varieties.
- Possibilities to reduce the dose rate of Shirlan are more feasible in the first half of the season than in the second part of the season for several varieties.
- If dose rate reductions are based on resistance ratings, reliable resistance ratings for both leaf and tuber blight are crucial.
- In the second half of the season tuber blight must be taken into consideration, which limits possibilities to reduce the dose rates for several but not all varieties.

### References:

- Anonymus, 2007. 81<sup>nd</sup> list of varieties of field crops 2007. Bonthuis H, Donner DA, Van Viegen A (eds).CSAR & RVP, Ede, 220 p.
- Clayton, R.C., R.C. Shattock, 1995. Reduced fungicide inputs to control *Phytophthora infestans* in potato cultivars with high levels of polygenic resistance. Potato Research 38: 399-405.
- Fry, W.E., 1975. Integrated effects of polygenic resistance and a protective fungicide on development of potato late blight. Phytopathology 65: 908-911.
- Kessel, G.J.T., W.G. Flier, H.G. Spits, J.G. Wander and H.T.A.M. Schepers, 2004. Exploitation of cultivar resistance using reduced fungicide dose rates, the Wageningen UR approach. In: PPO-Special report no 10, 211 – 214. C.E. Westerdijk and H.T.A.M Schepers, Editors.
- Nærstad, R.E., 2002. Exploitation of cultivar resistance in potato late blight disease management and some aspects of variation in *Phytophthora infestans*. Agricultural University of Norway.