

Definition of thresholds for soil moisture to assess zoospore infections by *Phytophthora infestans*

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SUMMARY

Potato tubers, which are infected with *Phytophthora infestans*, are able to release sporangia and zoospores in the ambient soil, when temperature and soil moisture are optimal for the fungus. In a field-experiment inoculated potato tubers were buried next to healthy tubers. In this way the possibilities for movements of zoospores through water-filled pores within the soil should be tested. Because of the diameter of zoospores at least all pore sizes smaller than 10 µm have to be filled completely with water. This fact led to a determination of a “limiting infection value” in relation to soil moisture. It was assumed that if soil moisture is below this limit zoospore movements are impossible. In the field-experiment could be seen, that the localisation of the limiting infection value varies among the different irrigated plots. For this reason further studies are required to specify the influence of soil type and maybe other so far unknown soil factors on the localisation of the limiting infection value.

KEYWORDS

Phytophthora infestans, soil moisture, zoospore infections, latent infected tubers, SIMBLIGHT1

INTRODUCTION

The prediction model SIMBLIGHT1 calculates the first appearance of *Phytophthora infestans* in potatoes in fields. These forecasts are based on meteorological data and crop characteristics (Figure 1). Studies done in the past have shown, that a correlation between high soil moisture after planting and early occurrence of *P. infestans* can be assumed. The aim of this current study is to specify the relation between soil characteristics and first appearance of *P. infestans*.

In addition the possibilities of soil water content simulations were tested. Therefore a bucket model was verified with the data collected in this study. Both, the relation between soil characteristics and appearance of *P. infestans* as well as the possibility of simulating the soil water content, should lead to an integration of a soil-module in SIMBLIGHT1.

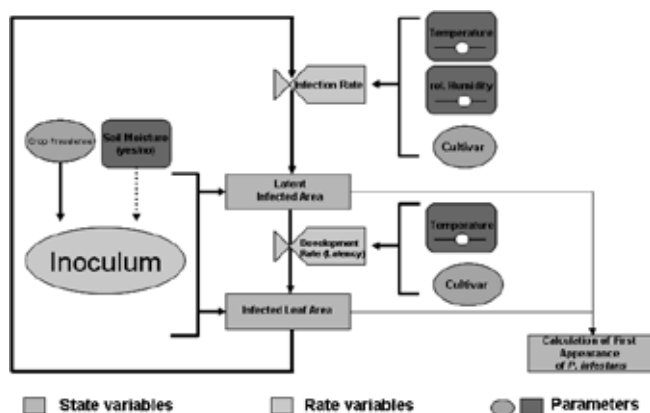


Figure 1: Structure diagram of SIMBLIGHT1 (Kleinhenz *et al.* 2007)

HYPOTHESIS

Potato tubers, which are infected with *P. infestans*, are able to release sporangia and zoospores in the ambient soil, when temperature and soil moisture are optimal for the fungus (Zan, 1962; Lacey, 1967; Sato, 1980; Adler, 2000; Porter, 2005).

With a diameter from up to 36 μm sporangia of *P. infestans* are hardly able to pass through soil pores. Zoospores of *P. infestans* instead have only a diameter of 10 μm (Porter *et al.*, 2005). They have the ability to move through water-filled pores within the soil. In this way zoospores are able to infect potato sprouts from the tuber they arise and neighbour tubers respectively (Figure 2).

Spore movement through soil depends on pore size distribution and size of water-filled pores. Saturation of soil starts within small pore sizes, which have a high water potential. For movement of zoospores all pore sizes smaller than 10 μm have to be filled completely with water.

In years, which offer high soil moisture on the plots over a period of at least 4 days the possibility for movements of zoospores exists. This process increases the risk of an early appearance of *P. infestans* in field. The effect of soil moisture on potato tuber infection due to *P. infestans* was assessed in a field-experiment.

MATERIAL AND METHODS

Inoculated potato tubers were buried next to healthy tubers in a sugar-beet field. It was necessary to do the field experiment surrounded by culture not susceptible to *P. infestans* and in a potato free growing area to avoid *P. infestans* infections from outside the trial plot. Afterwards the potato field was divided into four plots. Each plot consisted of 10 rows with a length form 7 meters planted with potatoes. Inoculated tubers were only buried in the middle of each plot. In this way twenty inoculated tubers were used as inoculum source to infect healthy tubers in every plot. To approve the theory of a higher transfer from zoospores out of an infected seed stock in relation to a longer existence of high soil moisture, each plot was treated with a different number of irrigation-days (8, 4, 2 days of irrigation and one plot with no irrigation – Figure 2). In the irrigated plots 50 litre water per square meter were given each day.

Soil moisture was measured gravimetric every two days. Therefore an undisturbed soil sample was taken with a soil sample ring. In each plot six soil samples were taken. In this way the average soil moisture of each plot could be analysed. In addition the pore size distribution of the plots was analysed weekly. In this way the possibility for movements of zoospores could be analysed.

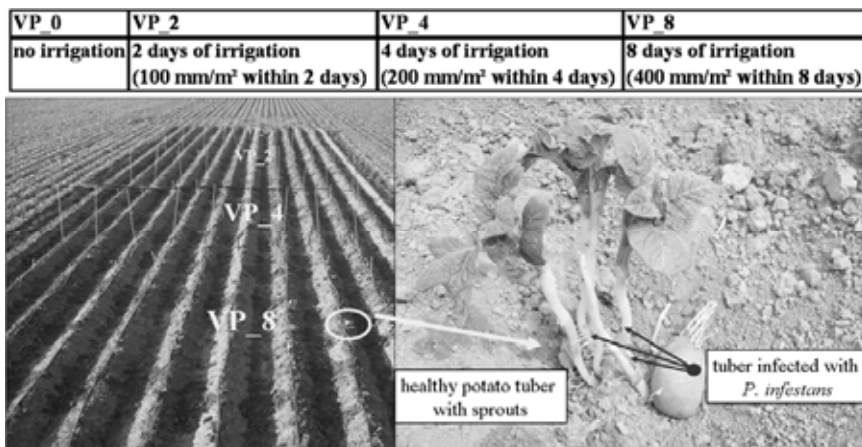


Figure 2: Arrangement of field-experiment and concept of buried transfer of zoospores from infected potato tubers

RESULTS AND DISCUSSION

Field experiment

The hypotheses that spore movement through soil depends on pore size distribution and size of water-filled pores led to the determination of a “limiting infection value“ in relation to pore size distribution (Figure 3). Water saturation of soil starts within small pore sizes, which have a high water potential. For movement of zoospores all pore sizes smaller than 10 μm have to be filled completely with water. This threshold is identical with the created limiting infection value. For possible movements of zoospores the soil moisture has to be above this border.

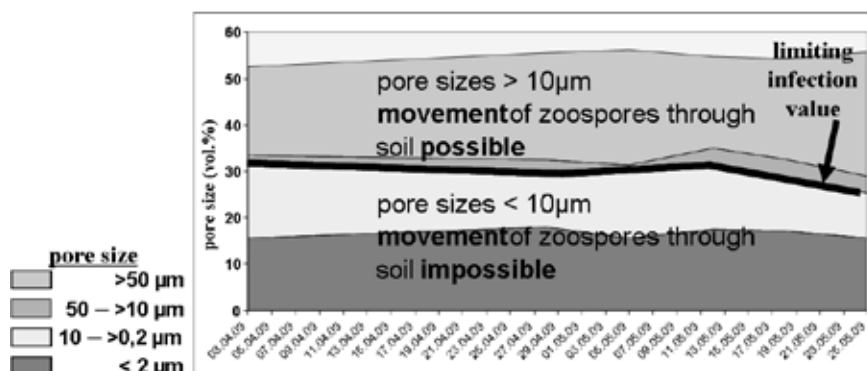


Figure 3: Determination of the limiting infection value on movement of zoospores from *P. infestans* through soil

In the field-experiment it could be seen, that the localisation of the limiting infection value depends on the amount of irrigation. As irrigation leads to consolidation, there must be a dislocation of the limiting infection value. Figure 4 shows the different limiting infection values of each plot. These facts lead to some different effects: The mean soil moisture in the plots differs about 5 % by vol. (Figure 4 – 1.), but in all cases the limiting infection value for the related plot is reached. The mean soil moisture in each plot is nearly identical, but the limiting infection value is only reached in one plot (Figure 4 – 2.).

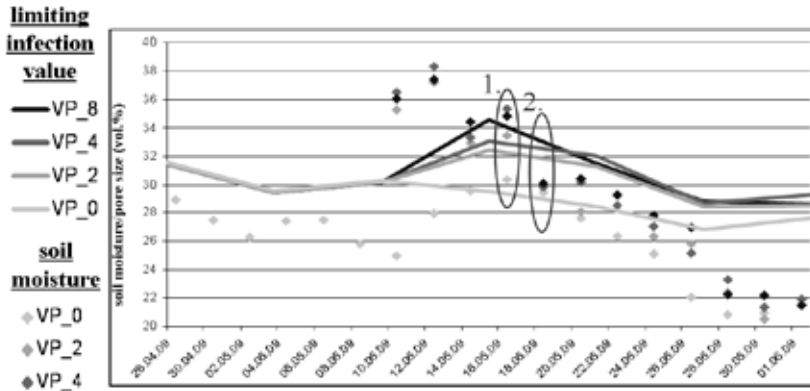


Figure 4: Comparison of the development of the limiting infection value in relation to soil moisture

Simulation of soil moisture

Soil moisture was measured directly every two days in a very time-intensive procedure within the field-experiment. A practical solution could be using so called bucket models. They simulate the soil water content with simple and generally available data from weather stations.

A first correlation between field-data and simulation shows promising results. Most of the deviations lie in a range of 5 % by vol. (Figure 5). This is identical with the variability of field-data within a plot.

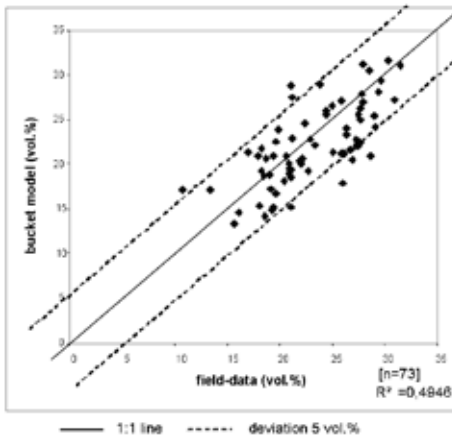


Figure 5: Correlation of the results of the bucket model with field-data

CONCLUSIONS

The influence of soil moisture on the limiting infection value could be shown in this field-experiment. Further studies are required to specify the influence of soil type and maybe other so far unknown soil factors on the localisation of the limiting infection value. The verification of the bucket model for the simulation of soil water content showed promising results (deviations were within the range of variations in field). These results build a good fundament for the integration of soil parameters in a soil-module in SIMBLIGHT1.

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