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# INCIDENCE AND HARMFULNESS OF POTATO LATE BLIGHT (*PHYTOPHTHORA INFESTANS* MONT. DE BARY) ON POTATO STEMS

## ABSTRACT

Changes in the occurrence of the initial late blight symptoms have been noted in some regions of Poland. Observations of potato crops showed that occurrence of the primary infections and blight symptoms is sometimes on the stem rather than on the leaves. It was confirmed that in both cases, a cause of late blight was the same species *Phytophthora infestans.* Surveys of many potato crops done in 1997-1999, around Poland enabled assessment of the incidence of stem blight in Poland. In 1997 - 80.5%, 1998 - 65.2% and in 1999 – 72.4% of observed crops were primary affected with late blight on stems. Stem form of the disease appeared more often in the years with less rainfall in the period from June to July. The largest number of genotypes with initial blight symptoms on stems was observed among first early clones and cultivars.

Glasshouse experiments confirmed the importance of stem lesions in decreasing yield and increasing tuber infection. Results confim that blighted tubers were the least probable source of the late blight appearing on stems.

*Key words:* diseases, late blight, *Phytophthora infestans*, potato, localization of initial late blight infection

## INTRODUCTION

The potato is one of the most important agricultural crops in Poland. Potato acreage has halved during the last twenty years, but still remains at a very high level. The area of potato crops in Poland was about 1 250 000 ha in 1999.

Late blight caused by *Phytophthora infestans* is the major disease which affects the potato crop and reduces yields. Reduction of yields comes under two headings: the loss of yield due to premature defoliation, which depends on the date of outbreak, and the rate of disease development, and losses of yield due to tuber infection. In Poland we have observed many changes in the *P. infestans* populations, like in whole of Europe (Spielman *et al.* 1991). One of them is

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change in the occurrence of the primary late blight infection and its symptoms on potato plants.

Blight on the foliage typically produces decaying spots on the leaves. Leaf symptoms appear initially as water-soaked, pale green to brown areas, sometimes bordered by a pale green or light yellow halo. Under wet weather conditions, a fine, white, moldy growth of the fungus sporangiophores may appear on the bottom surface, on the margins of the infected area (Friend 1991, Borecki 1996).

Whether blight first infects the leaves above or below the leaf canopy depends on the weather. In windy weather early infection may be restricted to the moist microclimate below the canopy. It happens in calm humid conditions to find the first infections on exposed young growth. This is particular so in the variety King Edward where the young shoot tips may even be affected before the leaves (Gunn et al. 1990). In humidity conditions late blight develops very intensively, destroying at first leaves, later stems and at last whole plants. Dry and hot air temperature during growing season, stops sometimes development of the disease by drying off leaves and leaf lesions.

If blight develops early in the season when the plants are young, the initial infections and the first disease symptoms may be confined sometimes to the stems of potato plants as stem blight (Shattock 1988, Rowe 1996). In this case stem lesions are initiated by direct the fungus infection. Infection of the stem tissue progresses rapidly, resulting in oily, brown lesions that later turn black. Lesions may extend along and around the stem. When sporangia production is at its greatest (when the plants began to senesce), sporangiophores are produced along the whole length of the lesion and unlike leaf lesions, are not largely restricted to the margin of the lesion.

Prior to 1994, in our country, there were only occasional reports of initial late blight infection occurrence on potato stems (Rudkiewicz 1975, Choroszewski,1993). In recent growing seasons the late blight often started very early and the first symptoms of the disease appeared on stems. The most of fungicides registered as the suitable ones for late blight control were not effective against the late blight developing on stems, if they were used according to the recommended standards and technical applications. In the framework of observations and experiments undertaken at the Institute in Bonin focusing on the quantity problem of primary blight infections on stems and its consequences for disease management, we needed information about incidence and harmfulness of stem blight at potato crops. This paper is a part of our work which was to explain some unanswered earlier questions connected with that problem.

## MATERIAL AND METHODS

### *1. Incidence of stem blight on potato crops - field observations:*

a) From 1995 to 1999, observations on the incidence of initial late blight infections on stems were made in state field trials in Bonin among advanced potato breeding clones and cultivars, . Each year appearance of the disease on stems was assessed on 22-84 potato genotypes. At the beginning of each season, plots (100 potato plants per plot)) were carefully inspected several times a week in order to detect localization of the initial, natural infections of late blight. Observations of the disease development (evaluated using 9-degree scale) were continued during growing season (once a week) up to haulm destruction. To compare weather conditions and their influence on late blight pressing, each year the same two standard cultivars: Atol and Cisa to make the observations of the late blight. The level of foliar blight infection of these cultivars was expressed in terms of the rate of infection (Plank van der 1963).

b) From 1997 to 1999, surveys of potato crops were undertaken to supply information about the incidence of initial blight infections on stems around Poland. Most of the information was received from commercial potato crops by workers of the Advisory Agriculture Service in cooperation with our Institute. Results were gathered in questionnaires which had been prepared earlier by Disease Laboratory. After growing season the questionnaires were sent to Bonin to estimate the results . Observations were made in 149, 158, 76 fields respectively in 1997, 1998 and 1999 . The observations were to give information about the majority of initial late blight infection localization on potato plants (stems or leaves, level of plant: top, middle part, bottom), dates of the disease appearance. In questionnaires we had additionalin formation, useful for us, e.g.: cultivar, date of planting, development of blight, chemical control, date of harvesting and yield.

### *2. Defining source of stem blight infection and its effect on the yield and incidence of tuber blight in progeny tubers - glasshouse experiment:*

Potato plants of the Atol cultivar (susceptible to late blight) were grown in glasshouse in 30 kg polyethylene bags with soil at 18°C and 70% relative humidity. All plants were inoculated in different ways with a suspension of *P. infestans* at concentration 25 sporangia × $mm^{-3}$:

- spraying of seed tubers (7 days before planting) with 5 ml of suspension per tuber,
- spraying of whole, 3-week old plants with 10 ml of suspension per plant,
- stem inoculating of 3-week old plants by injection (2 stems / plant, 5 cm above the soil surface) with 2 ml of suspension per injection point.

Control plants were left without the pathogen inoculation. Inoculated plants (sprayed and injected) were covered with plastic bags for 8 hours

to maintain high humidity favouring late blight infection. Then the plants were kept at 16°C and 70% relative humidity (RH) for 24 hours, later at 18°C and 80-90% RH, under 12 h light/dark regime. The experiment was carried out using 4 replicate plants (12 „pots") for each treatment. The position of the first symptoms of late blight, the size of stem lesions and degree of leaf destruction were measured every 3 days during plant growing, on all plants. Tuber yield from each combination of 12 plants was harvested at 100 days after planting. Tubers were weighed and scored for tuber late blight infection. Blighted tubers were calculated as per cent of yield weight.

## RESULTS AND DISCUSSION

1 a). Observations of breeding material done during the recent five years showed various number of genotypes affected with potato stem form of blight each year. Its incidence was not connected with the rate of the leaf form of late blight developing on the foliage. There was a poor relationship between the number of genotypes with initially infected stems and foliar blight risk observed on the control cultivars. The greatest number of breeding clones and cultivars affected with stem blight occurred in 1997 (51.3%), whereas foliage blight developed the most intensively in 1996. Results of our observations tended to show that stem blight appeared more often in the years with less rainfall, mainly during June and July (see years: 1997 and 1999 compare to 1995 and 1998) - Table 1.

Table 1

**Incidence of initial late blight infection on stems - potato field at Bonin**

| Years | Rainfalls during June-July [mm] | €Number of observed genotypes€ | % of genotypes with blight infection on stems | Rate of foliar late blight development on control cvs | |
|---|---|---|---|---|---|
| | | | | Atol | Cisa |
| 1995 | 237.9 | 83 | 25.3 | 0.271 | 0.155 |
| 1996 | 224.8 | 84 | 36.9 | 0.289 | 0.279 |
| 1997 | 106.4 | 80 | 51.3 | 0.210 | 0.204 |
| 1998 | 270.0 | 80 | 22.5 | 0.226 | 0.210 |
| 1999 | 122.6 | 22 | 45.5 | 0.194 | 0.175 |
| | | | LSD (p=0.05) | 0.029 | |

Our observations showed also that development of stem lesions can be continued at the weather conditions too hot and dry for the foliar blight . Some authors report that many infected leaves abscise prematurely under these circumstances and therefore they does not act longer as a source of inoculum for disease spreading when the weather conditions favourable for blight return (Weihing and O'Keefe 1962). In contrast, Clayson and Robertson (1956) reported that stem lesions continued to enlarge during a hot, dry period of 40 days when the weather became favour-

able for *P. infestans*. Shattock (1988) confirmed that stem lesions later serve to maintain the focus of disease in less favourable dry weather.

The largest number of genotypes with initial late blight symptoms on stems was observed among first early clones. Equal numbers of genotypes of each maturity were affected with stem blight in 1996 only. In 1997 and 1998 the fewest main crop genotypes were affected with stem blight (Fig.1).

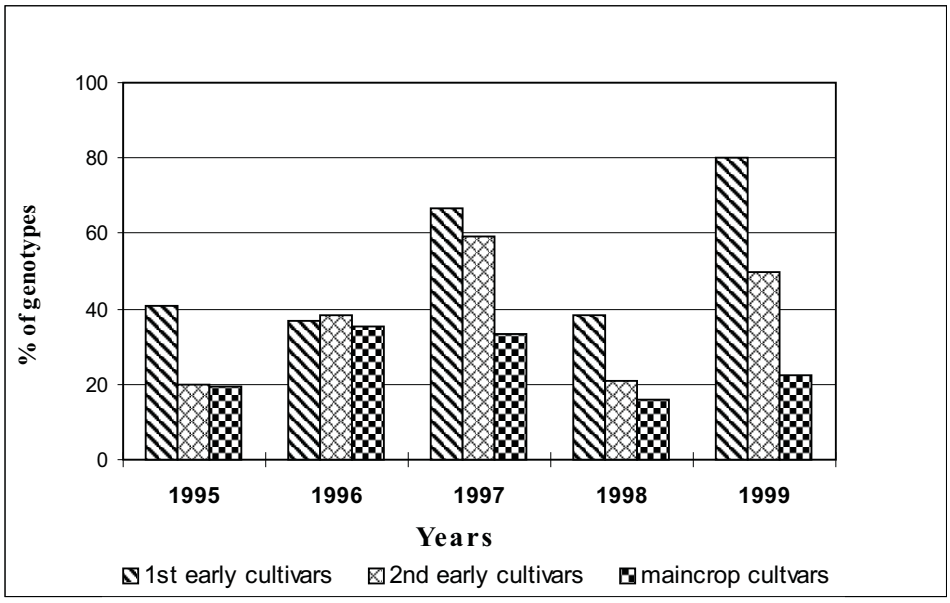


Fig. 1 Incidence of primary late blight infections on potato stems on cultivars varied in their maturity (% of observed genotypes)

1 b). Surveys of many potato crops done in 1997-1999, around the country enabled assessment of the incidence of stem blight in Poland. Respectively: 80.5% - in 1997, 65.2% - in 1998 and 72.4% - in 1999 of all observed crops were primary affected with blight on stems. The stem form of potato late blight appeared mostly 71-80 days after planting. Sometimes (in 1999) it appeared much earlier, 50-60 days after potato planting (Table 2). Information about the time of stem blight appearance is very important for plant protection practice. In Poland, blight forecasting systems are still working out. Because the fungicides effective against stem blight are mainly systemic, spraying must start in advance of blight appearing in the crop. Timing of the first application against late blight is usually determined from experience of the seasonal occurrence of blight in the locality. In Poland we advised our farmers that the first precautionary spraying should be applied 50-60 days after planting.

Table 2

**Time of potato late blight appearance (days after planting) - % of observed potato crops**

| Time of appearance [days after planting] | Years | | | | | |
|---|---|---|---|---|---|---|
| | 1997 | | 1998 | | 1999 | |
| | Stems | Leaves | Stems | Leaves | Stems | Leaves |
| < 60 | 7.8 | 9.9 | 16.9 | 15.8 | 29.1 | 21.9 |
| 61 - 70 | 19.1 | 21.0 | 25.5 | 30.9 | 2.3 | 32.9 |
| 71 - 80 | 29.6 | 25.9 | 30.6 | 25.0 | 16.4 | 23.3 |
| 81 - 90 | 21.7 | 24.7 | 14.3 | 19.1 | 18.2 | 13.7 |
| 91 - 100 | 13.1 | 13.6 | 6.2 | 5.3 | 3.6 | 8.2 |
| > 101 | 8.7 | 4.9 | 7.1 | 3.9 | 5.5 | 0.0 |
| Number of observed potato crops | 149 | | 158 | | 76 | |

Observations of the localisation of the first stem blight symptoms were carried out on 278 potato fields around the country in 1997-1999. Each year the first stem symptoms were observed mainly (more than 50%) in the middle parts of the potato plants. Stem infection rarely started at the bottom of the plants (Table 3). Our results do not confirm the general opinion that stem late blight symptoms are mainly confined to the tops of potato plants (Shattock 1988). Most of stem infections started in the middle part of potato plants. The specific microclimate under well developed leaves, with humidity favouring blight infection on stems was probably the reason of it, whereas the relative humidity is not high enough to start infection of outer leaves. The fewest infections started at the bottom of potato plants but we did not observe any systemic infection from tubers. The observations showed that blighted tubers were the least probable source of the late blight (also on stems) although blighted tubers are known as one of a primary source of late blight epidemics in season. Inoculated seed tubers also produced sporangia, although infection of the haulm from this source was not

Table 3

**Position of the first symptoms of stem late blight - *P.infestans* on potato plants - % of observed potato crops**

| Position of the first stem symptoms | Years | | |
|---|---|---|---|
| | 1997 | 1998 | 1999 |
| Top of plant | 33.1 | 34.8 | 30.4 |
| Middle part | 54.2 | 53.9 | 62.3 |
| Bottom | 12.7 | 11.3 | 7.3 |
| Number of observed potato crops | 120 | 103 | 55 |

proved (Lacey 1967a). Under certain conditions water can run from the seed tubers to the furrows .

2. Defining the source of the late blight on stems infection and its influence on progeny tuber yield is very difficult in the potato field. In natural conditions, during the growing season, one form of the disease develops very seldom until harvest time. Forms of late blight are followed one to another. Better results could be obtained when experiments were carried out in the glasshouse. In our tests potato plants were inoculated in different ways to get late blight symptoms on stems. Environmental conditions in the glasshouse caused late blight symptoms mainly on stems. Only one blight spot was met on leaves. Lower humidity in glasshouse was favourable for starting infections on stems. For leaf infections more favourable is higher humidity >90% (Shattock 1988).

Table 4

**Influence of various inoculation methods on the size of stem lesions, tuber yield and tuber infection by late blight (mean of 12 plants)**

| Method of inoculation | Mean size of stem lesions [mm] | Tuber yield [% of control yield] | Tuber blight [%] |
|---|---|---|---|
| Control (without inoculation) | 0.0 | 100.0 | 0.0 |
| Blighted seed tubers | 13.0 | 88.8 | 0.34 |
| Spraying of plants | 83.1 | 57.1 | 1.04 |
| Inoculation of stems | 5.9 | 64.2 | 0.77 |
| LSD (p=0.05) | 20.3 | 15.3 | no significant |

Infected stems tuber yield decrease (11.2-42.9%) was observed and each time, giving blighted progeny tubers (Table 4).

The best method of inoculation was spraying the plants with *P. infestans*. That method gave the largest stem lesions (length of all stem lesions = 155.1 mm) and the greatest decrease in tuber yield (42.9%). The results of that method were clearer even in comparison to straight inoculation of the stem (length of all stem lesions = 121.4 mm) because it gave more infection points on the plants. It was confirmed again that blighted tubers were the least probable direct source of the blight stem forms (length of stem lesions = 13.0 mm). Shattock (1988) concluded that in natural conditions stem and leaves initially become infected by contact with disease tubers or from soil-borne inocula originating from blighted tubers. Systemically infected shoots can develop occasionally from diseased tubers but these usually deteriorate and fail to emerge above soil level.

The results presented in this paper show that in the absence of foliar lesions, caused by conditions unfavourable for their development (lower relative humidity), *P. infestans* inoculum produced on lesions located at the potato stems can infects progeny tubers. Blighted tubers were harvested only from 1-3 „pots" for combination. We conclude that they were in-

fected during the „growing season" and stem lesions were the source of blight inoculum for progeny tuber infection in glasshouse. Relative humidity 70-80%, favourable for stem lesions occurrence, are not very favourable for their abundant sporulation. It was the reason of low tuber blight, on an average per combination. The highest per cent of tubers infected with late blight was observed when plants were treated with spraying. Percent of blighted tubers did not differ statistically between treatments. Our results confirm results of others, showing the importance of *P. infestans* inoculum from stem lesions as an important source of tuber infection (Bain et al.1996, Lammers et al. 1998). Lapwood (1964) reported 30% tuber blight in field plots of King Edward where only few blight lesions on the leaves but abundant stem lesions were found. Lacey (1967 b) also observed high incidence of tuber infection close to the stems in pot-grown potato plants. There is an evidence that the sporangia on stem lesions can be readily transported in water channeled down the stems to infect the tubers.

## CONCLUSIONS

1. Sometimes initial late blight infections started on potato stems (stem blight) what was confirmed by some observations of potato crops. Stem form of the disease appeared more often in the years with less rainfall during the period from June to July.
2. The largest number of genotypes with stem blight symptoms was observed among first early clones and cultivars, mostly 71-80 days after planting.
3. Observations carried out in 278 potato fields around the country showed that many of the stem infections (> 50%) started in the middle part of potato plants. It is important information for chemical blight control.
4. The blighted lesions on stems have decreased tuber yield and has given blighted progeny tubers.

## REFERENCES

Bain R. A., Fairlough R. W., Holmes S. J., Ligertwood G. L. 1996. The role of *Phytophthora infestans* inoculum from stem lesions in the infection of tubers. Proceedings of Workshop on the European network for development of an integrated control strategy of potato late blight. PAV-Special Report no.1: 98-105.

Borecki Z. 1996. Nauka o chorobach roślin. PWR i L. Warszawa 1996: 370 pp.

Choroszewski P. 1993. Chapter 2.6 Ochrona In: Produkcja ziemniaków. Technologia Ekonomika Marketing. Ed. J. Chotkowski Bonin 1993, 454 pp.

Clayson A. M., Robertson N. F. 1956. Survival of *Phytophthora infestans* in potato stem lesions. Plant Pathol. 5: 30-31.

Gunn J. S., 1990. Crop protection handbook - potatoes. Ed. British Crop Protection Council, 192 pp.

Friend J. 1991: Host -pathogen interactions current questions. Eds. Lucas J. A., Shattock R. C., Shaw D. S. & Cooke L. R. Phytophthora. Cambridge University Press: 46-49.

Lacey J. 1967 a. The role of water in the spread of *Phytophthora infestans* in the potato crop. Ann. Appl. Biol. 59: 245-255.

Lacey J. 1967 b. Susceptibility of potato tubers to infection by *Phytophthora infestans*. Ann. Appl. Biol. 59: 257-264.

Lammers J. W., Bain R. A., Ligertwood G. L., Raynor E. L. 1998. Sporangia production on leaf and stem lesions in relation to cultivar resistance to potato blight (*Phytophthora infestans*). Proceedings of Workshop on the European network for development of an integrated control strategy of potato late blight. PAV-Special Report no 3: 85-91,

Lapwood D. H.1964. Haulm and tuber resistance to blight (*Phytophthora infestans*). Rothamsted Experimental Station. Report for 1963: 11-112.

Plank J. E. van der 1963. Plant diseases: epidemics and control. Academic Press. New York. 349 pp.

Rowe R. C. 1996: Late blight biology - understanding the enemy. Proceedings of the 1996 Washington Potato Conference & Trade Show, 1-6

Rudkiewicz F. 1975. Terminy i efektywność stosowania fungicydów przeciwko zarazie ziemniaka (*Phytophthora infestans* (Mont.) de Bary). Ziemniak 1975: 5-66.

Shattock R. C. 1988. Phytophthora infestans. Eds. Smith I. M., Dunez J., Lelliott R. A., Phillips D. H., Archer S. A. European Handbook of Plant Diseases. Blackwell Scientific Publications: 202-204.

Spielman L. J., Dreenth A., Davidse L. C., Sujkowski L. J., Gu W., Tooley P. W., Fry W. E. 1991. A second world-wide migration and population displacement of *Phytophthora infestans.* Plant Pathol. 40: 422-430.

Weihing J. L., O'Keefe R. B. 1962. Epidemiological potentials of potato varieties in relation to late blight. Phytopathology 52: 1268-1273.