

## EFFICACY OF SOME SELECTED FUNGICIDES AGAINST EARLY BLIGHT (*ALTERNARIA* SPP.) ON POTATO CROPS

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**Abstract:** The studies conducted in two different localities revealed variable time of occurrence and severity level of potato early blight (*Alternaria* spp.). Each year at Stare Olesno the early blight caused considerable destruction of potato plants (90.2%–95.4%) while at Bonin the disease severity differed in particular years and ranged from 50.0% to 97.5% of destructed plants at the end of the growing season. Field trials showed good efficacy of fungicides selected for controlling the early blight compared with an untreated control. Spraying with fungicides limited development of the disease and increased tuber yield in the range from 21.9% to 60.9% for Bonin and from 13.0% to 101.9% for Stare Olesno surveys. The mixture of zoxamide with mancozeb showed the greatest efficacy.

**Keywords:** potato, early blight, control of disease, fungicide efficacy

### INTRODUCTION

The potato is one of the most important agricultural crops in Poland. The area of potato crops in Poland was about 0.8 million ha in 2002. Diseases occurring during the growing season and in storage are factors causing high losses in potato yield worldwide.

Late blight caused by *Phytophthora infestans*, well known around the world, is the major disease, which affects the potato crops and reduces yields up to 70% on unprotected crops (Hoffman & Schmutterer 1983). Because late blight can affect potatoes at any stage of growth, early epidemics can lead to 100% loss (Fry 1994). In Poland average losses are estimated for 20–25% (Pietkiewicz 1989).

Early blight occurs commonly worldwide on potato crops, particularly in regions with high temperature and humidity. Harmfulness of early blight is estimated differently in various regions of the world. According to Reinoch (1974), the disease

reduces yields up to 25%, locally 60%. According to Fry (1994), maximum documented yield reductions are usually 20–30%. In Polish climatic conditions there were recorded high regional losses caused by the early blight, however, most related to cultivars with recognized susceptibility to this disease.

In the years 1997–2001 studies were conducted at the Plant Breeding and Acclimatization Institute in Bonin with the emphasis on:

- comparison of time of the occurrence and severity level of the early blight of potato in two different locations,
- estimation of the efficiency of selected fungicides in limiting the development of the early blight.

## MATERIALS AND METHODS

Observations and field trials were carried out in 2 sites differing with climatic conditions (Bonin – in northern Poland and Stare Olesno – in southern Poland). A randomized complete block design with 4 replications was used for the experiment. Each plot was 30 m<sup>2</sup>. Estimation of fungicide efficiency to control the early blight was performed on potato cv. Frezja (very susceptible to the disease).

In the early blight control there were compared protectant fungicides such as mancozeb (Dithane M-45 80 WP) and chlorothalonil (Bravo 500 SC) and also mixtures of plant protection products with a contact mode of action i.e. zoxamide with mancozeb (Unikat 75 WG). All treatments were applied at a dose of 2 kg (l) per ha. Two treatments at 7–10 day intervals (in the years 1997, 1999 and 2001) and three (in 1998 – the year with high infection pressure of pathogen) were performed throughout the growing season beginning with the occurrence of the very first symptoms of the disease on the experimental plots. In field trials an untreated plot was a check. Then, the same protection program against late blight was continued at all plots up to the first decade of August.

The criteria for fungicide effectiveness assessment was assumed to be the percentage of haulm destruction at the end of growing season (percentage of infected plants), area under disease progress curve – AUDPC (Fry 1978; Shaner & Finney 1977) and also tuber yield. The results were analyzed in a 2-factorial ANOVA, the factors being years of experiments and the fungicide applied.

## RESULTS

The studies carried out at Bonin and Stare Olesno revealed that both time of occurrence and the severity of the early blight differed and were dependent upon weather conditions (Fig. 1) and upon which year the survey was conducted (Tab. 1).

The early blight occurred the earliest at Bonin in 2001 (June 15) and at Stare Olesno in 1998 (June 12). In both localities, under their climatic conditions, the early blight occurred earlier than the late blight by 4–29 days.

Weather conditions in Stare Olesno (in southern Poland) particularly favored early blight appearance. Each year at Stare Olesno the early blight caused considerable high destruction of potato plants (90.2–95.4%) while at Bonin the disease severity differed in particular years and the plant destruction ranged from 50.0 to 97.5 (Tab. 2) at the end of the growing season. Also at Stare Olesno a very high infection

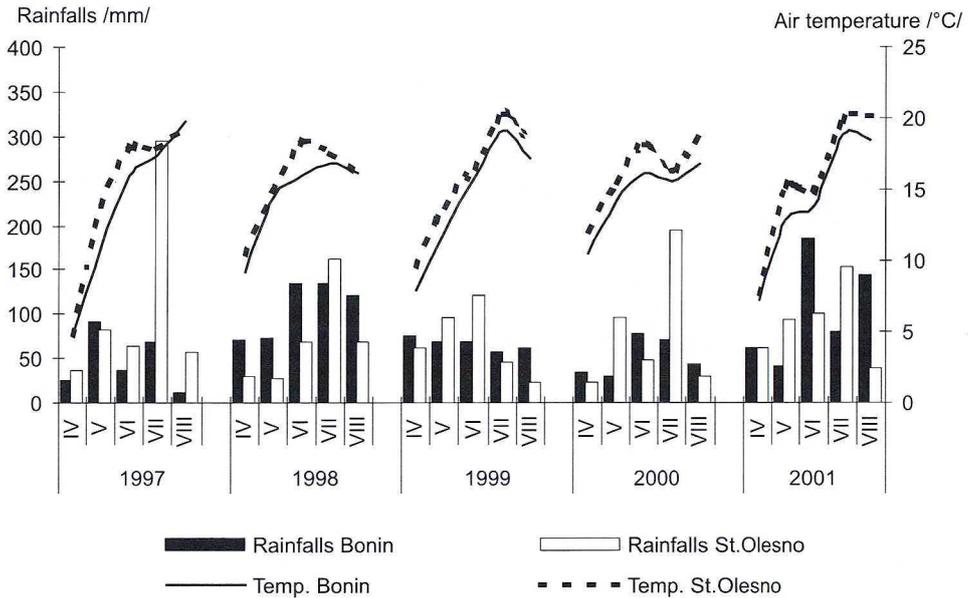


Fig. 1. Weather conditions (rainfalls and air temperatures) at Bonin and Stare Olesno in the years 1997–2001

Table 1. Time of appearance of early blight in the years 1997–2001

Locality	1997	1998	1999	2000	2001
Bonin	30.06.	18.06.	18.06.	19.06.	15.06.
Stare Olesno	01.07.	12.06.	14.06.	20.06.	26.06.

Table 2. Early blight severity on cv. Frezja (years 1997–2001)

Locality	1997		1998		1999		2000		2001	
	Disease severity %	AU DPC								
Bonin	64.3	0.194	97.2	0.260	50.0	0.161	83.4	0.214	92.5	0.195
Stare Olesno	95.4	0.319	93.4	0.497	94.4	0.342	100.0	0.432	90.2	0.523

rate of the pathogen was observed, particularly in 1998 and 2001. In these years the area under the disease progress curve (AUDPC) on the unprotected cultivar was 0.497 and 0.523, respectively. The highest AUDPC value obtained at Bonin in 1998 did not exceed 0.260.

The conducted trials showed that all fungicides limited the early blight development compared to the untreated control.

In Bonin climatic conditions, all tested fungicides revealed similar efficiency in inhibition of the disease development (Tab. 3). In the years 1997, 1998 and 2001 there were not any significant differences in the disease level on plots protected with all tested fungicides. Only in the year 1999, when the early blight severity was

the lowest, the applied mancozeb and its mixture with zoxamide gave better protective results as compared with chlorothalonil treatment.

The comparison of the area under the disease progress curve (AUDPC) for a particular treatment confirmed that the utilized fungicide clearly limited the disease development.

In Stare Olesno climatic conditions under high infection rate of the pathogen there was observed a distinct differentiation of protection efficiency for different fungicides (Tab. 4).

In years 1998 and 1999 the efficiency of the mixture zoxamide with mancozeb in controlling the early blight development was similar to that obtained for chlorothalonil and mancozeb. In other years (1997 and 2001) the effectiveness was significantly higher.

Table 3. Efficiency of selected fungicides in potato protection against early blight at Bonin (years 1997–1999, 2001)

Fungicide	1997		1998		1999		2001	
	Disease severity %*	AUDPC						
untreated	64.3 a	0.194 a	97.2 a	0.260 a	50.0 a	0.161 a	92.5 a	0.195 a
chlorothalonil	18.3 b	0.064 b	70.6 b	0.139 b	50.0 a	0.142 a	78.8 b	0.123 b
mancozeb	14.6 b	0.056 b	73.4 b	0.150 b	32.1 b	0.103 b	67.9 b	0.102 b
zoxamide + mzb	14.8 b	0.060 b	63.4 b	0.149 b	32.1 b	0.131 b	53.6 bc	0.107 b

\* Means followed by the same letter within column are not significantly different at  $\alpha=0.05$

Table 4. Efficiency of selected fungicides in potato protection against early blight at Stare Olesno (years 1997–1999, 2001)

Fungicide	1997		1998		1999		2001	
	Disease severity %*	AUDPC						
untreated	95.4 a	0.319 a	93.4 a	0.497 a	94.4 a	0.342 a	90.2 a	0.523 a
chlorothalonil	93.4 a	0.257 a	35.6 b	0.283 b	42.8 b	0.124 b	33.0 b	0.230 b
mancozeb	88.7 a	0.219 a	32.1 b	0.258 b	32.1 b	0.099 b	4.3 c	0.123 c
zoxamide + mzb	32.1 b	0.078 b	14.8 b	0.115 c	35.6 b	0.114 b	3.3 c	0.101 c

\* Means followed by the same letter within column are not significantly different at  $\alpha=0.05$

Table 5. Influence of protection against early blight on tuber yield – % of control (years 1997–1999, 2001)

Fungicide	Bonin				Stare Olesno			
	1997	1998	1999	2001	1997	1998	1999	2001
untreated	100	100	100	100	100	100	100	100
chlorothalonil	+ 51.9	+ 21.9	+ 7.0	-	+ 7.6	+ 13.0	+ 87.5	-
mancozeb	+ 38.1	+ 26.2	+ 9.4	+ 13.6	+ 21.1	+ 18.7	+ 98.1	+ 17.3
zoxamide + mzb	+ 60.9	+ 32.9	- 2.6	+ 12.5	+ 7.9	+ 19.6	+ 101.9	+ 15.0
LSD ( $\alpha=0.05$ )	29.3	26.5	ns	ns	ns	9.5	24.2	ns

ns – not significant difference

Protection against the early blight effected indirectly the tuber yield obtained from protected plots (Tab. 5).

The yield increase obtained from plots protected against the early blight was statistically insignificant in some years (Bonin – 1999 and 2001, Stare Olesno – 1997 and 2001). In the remaining years the significant differences, in comparison to the untreated control, were calculated in the range from 21.9% to 60.9% for Bonin surveys and from 13.0% to 101.9% for Stare Olesno surveys. There were no significant differences found between treatments.

## DISCUSSION

Early blight, seen as dry and brown leaf spotting is a common disease of potatoes due to the worldwide distribution of the causal agent. However, its harmfulness is greater in regions with higher temperature and humidity. Conidia and conidiphores are produced only under conditions of high humidity equal or above 90%. Sporulation increases along with temperature increases. High temperatures (the optimum temperature for *A. alternata* development is 25–26°C, for *A. solani* 26–27°C), alternating periods of dry weather and high humidity, frequent short rainfalls, abundant dews, and weaker plants create the optimum conditions for epidemic development (Hooker 1980). Also in the recent years fungus adaptation to lower temperatures has been observed.

The 5-years of studies conducted at Bonin and Stare Olesno revealed that the occurrence of the early blight depended mostly upon climatic conditions in particular years in both localities. Time of occurrence of the early blight depends upon meteorological conditions in third decade of June and first decade of July (Dorożkin & Iwaniuk 1979). Previous observations carried out in the years 1987–1995 in Poland in 18 Experimental Stations of Cultivar Testing showed significant differentiation in disease severity depending on locality as well as which year the survey was conducted (Kapsa & Osowski 1996).

In the foregoing investigations favorable conditions for the early blight occurrence were mainly observed in Stare Olesno (southern Poland). Higher temperatures in June and July in Stare Olesno (as compared with temperatures in Bonin) induced higher infection pressure of the pathogen. The climatic conditions in Stare Olesno also favor greater infection pressure of the viruses. As it has been noticed previously potato plants infected with some viruses are more susceptible to the early blight infection (Hooker 1980). This refers mainly to viruses PVY and PLRV (Dorożkin et al. 1979) and PVX (Nagaich & Prased 1971). Probably virus infections enlarged additionally early blight pressure under Stare Olesno conditions.

Earlier observation carried out around Poland showed that under Polish climatic conditions the early blight occurred earlier than the late blight during the growing season. However, the important fact is that all observations were carried out on unirrigated fields and existing climatic conditions favored natural infection with the early blight.

The proper protection against the pathogen relies on few basics, among other things, the selection of fungicide, an application at appropriate dose, time of season, and correct spraying technique. Configuration of meteorological conditions

during the growing season also affects the pathogen incidence. Fungicide efficiency is the essential factor in proper protection.

The field trials showed a good efficiency of all selected fungicides in controlling the early blight compared with the untreated control. The sprayings limited the development of disease and increased the tuber yield. The mixture zoxamide with mancozeb gave the best efficiency.

Some investigators indicate low sensitivity of pathogens from *Alternaria* genus to most fungicides including almost all-systemic products (Borecki 1996). On the other hand the same author indicates that mancozeb gives a good efficiency in control of these diseases and he also recommends mancozeb, metiram, propamocarb and chlorothalonil for a control of *Deuteromycotina* fungi (*Alternaria* belongs to them). Osowski (1998) and Kapsa (2000) obtained similar results.

Various active ingredients are registered for the control of the early blight in different countries. In Poland this list includes chlorothalonil (Bravo, Clortosip, Gwarant), fluazinam (Altima), metiram (Polyram), and famoxadone+cymoxanil (Tanos). It is well known that in case of the early blight, the disease, which is difficult to control, the efficiency of applied fungicide (in field conditions) at a level of 60–70% is satisfactory. Despite that, Fry (1994) and Stevenson & James (1997) recommend routine chemical treatments against the early blight.

Another question is the timing of performing treatments against the early blight. In Polish climatic conditions the early blight usually occurs in June. Our recommendations regarding the first chemical treatment for protection of susceptible cultivars indicate that, the appearance of the first disease symptoms on potato leaves, is the optimum time for initiating applications of fungicides. Even some early studies on this subject (Harrison et al. 1965; Dorożkin 1972 in Reinoch 1974) revealed that earlier chemical applications are not significant. According to them fungicides applied at the beginning of the second infection give efficient results.

Each year at Stare Olesno a significant increase of tuber yield from protected plots was recorded as compared with the untreated control. At Bonin the yield increase was noted only in some years. Generally the late blight occurs earlier in southern Poland (Stare Olesno) than in northern regions. Earlier destruction of above ground plant parts holding the tuber growth causes greater effect to tuber yield. It might explain more clearly influenced of the fungicide protection on the tuber yield, as compared with the untreated control at Stare Olesno.

Good efficiency of selected fungicides in control of early and late blight means the same products can be used in the control of both diseases, preventive in the late blight control and curative in the early blight control.

## CONCLUSIONS

1. In both localities (Bonin and Stare Olesno) incidence of the early blight and its severity varied depending on climatic factors.
2. In both localities tested fungicides demonstrated good efficacy in the inhibition of the early blight development compared to the unprotected control. The efficacy of zoxamide and mancozeb mixture was the best in most of the years.

3. Result of effective protection of potato plots against the early blight was an increase in tuber yield compared with the control in the range from 21.9% to 60.9% for Bonin surveys and from 13.0% to 101.9% for Stare Olesno surveys.

## REFERENCES

- Borecki Z. 1996. Nauka o chorobach roślin. PWRiL Warszawa 1996, 370 pp.
- Droby S., Dinooor A., Prusky D., Barkai-Golan R. 1984. Pathogenicity of *Alternaria alternata* on potato in Israel. *Phytopathology* 74: 537–542.
- Dorożkin N.A., Ivanjuk V.G. 1979. Epifitotii rannej suchoj piatnistosti kartofelja i tomatov. *Mikol. Fitopatol.*, 13, 4: 314–321.
- Dorożkin N.A., Ivanjuk V.G., Grebenšëikova S.I. 1979. Vlijanie virusnoj infekcii na porazenie kartofelja rannej suchoj pjatnistost'ju (*Macrosporium solani* Ell et Mart., *Alternaria solani* Sor.). *Kartofelev. i Plodoovošëev.*, 4: 56–61.
- Fry W.E. 1978. Quantification of general resistance of potato cultivars and fungicide effects for integrated control of potato late blight. *Phytopathology* 67: 415–420.
- Fry W.E. 1994. Role of early and late blight suppression in potato pest management. p.166–177. In “Advances in Potato Pest Biology and Management” (G.W. Zehnder, M.L. Powelson, R.K. Jansson, K.V. Raman, eds.). APS PRESS. The American Phytopathology Society St.Paul, Minnesota, USA, 655 pp.
- Harrison M.D., Livingston J.G., Oshima N. 1965. Control of potato early blight in Colorado. Fungicide spray schedules in relation to the epidemiology of the disease. *Am. Potato J.*, 42, 11: 319–327.
- Hooker W.J. (ed.). 1980. Compendio de enfermedades de la papa. Centro Intern. de la Papa, Lima – Peru, 166 pp.
- Hoffman G.M., Schmutterer H.O. 1983. Parasitäre Krankheiten und Schädlinge an landwirtschaftlichen Kulturpflanzen. Verlag Eugen Ulmer. Stuttgart.
- Kapsa J., Osowski J. 1996. Szkodliwość alternariozy ziemniaka i jej zwalczanie. [Harmfulness of potato early blight and its control]. p. 596–599. In: “Nowe kierunki w fitopatologii”. Sympozjum PTFit., Kraków.
- Kapsa J. 2000. Problem of potato early blight (*Alternaria* spp.) and its control in Poland. Dithane Symposium, Bandol, Francja. Potato Workshop: 23–34.
- Osowski J. 1998. Możliwości zwalczania alternariozy *Alternaria* spp. w badaniach laboratoryjnych i polowych. [Possibility of early blight *Alternaria* spp. control in laboratory and field experiences]. *Matateriały Konferencji “Ochrona Ziemniaka” Kołobrzeg*: 37–41.
- Nagaich B.B., Prased B. 1971. Interaction between *Alternaria solani* and potato wiruses X and Y. *Indian J. Exper. Biol.*, 9, 1: 88–90.
- Pietkiewicz J.B. 1989. Zwalczanie zarazy ziemniaka. Instrukcja upowszechnieniowa 1/89. Instytut Ziemniaka, Bonin, 20 pp.
- Reinoch M. 1974. Alternariozy ziemniaka. *Z Prac Instytutu Ziemniaka* 1/2: 19–28.
- Shaner G., Finney R.E. 1977. The effect of nitrogen fertilization on the expression of slow-mildewing resistance in Knox wheat. *Phytopathology* 67: 1051–1056.
- Stevenson W.R., James R.V. 1997. Improved Management of Early Blight and Late Blight: What have we learn from 1996?. *Proceeding of Wisconsin's Annual Potato Meetings*: 107–155.

## POLISH SUMMARY

SKUTECZNOŚĆ WYBRANYCH FUNGICYDÓW W ZWALCZANIU ALTERNARIOZY (*ALTERNARIA SPP.*) W UPRAWACH ZIEMNIAKA

Na plantacjach ziemniaka coraz większego znaczenia nabiera alternarioza (*Alternaria spp.*). W latach 1997–2001 w Instytucie Hodowli i Aklimatyzacji Roślin w Boninie podjęto badania nad zwalczaniem alternariozy ziemniaka. Celem badań było określenie terminu występowania i nasilenia alternariozy w dwóch miejscowościach, różniących się warunkami klimatycznymi oraz ocena skuteczności wybranych fungicydów w zwalczaniu choroby.

Każdego roku, w Starym Oleśnie (południowa część Polski) alternarioza powodowała znaczne zniszczenia roślin ziemniaka pod koniec okresu wegetacji (90,2%–95,4%), podczas gdy w Boninie (północna część Polski) nasilenie choroby wahało się w granicach od 50,0% do 97,5%.

W doświadczeniach polowych stwierdzono dobrą skuteczność wybranych fungicydów w zwalczaniu choroby w porównaniu do kombinacji kontrolnej. Stosowanie fungicydów zahamowało rozwój choroby i pośrednio wpłynęło na wzrost plonu w zakresie od 21,9% to 60,9% w Boninie i od 13,0% do 101,9% w Starym Oleśnie. Mieszanina zoksamidu i mankozebu wykazała najwyższą skuteczność, nie zawsze jednak w stopniu statystycznie istotnym.