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EFFECT OF ENVIRONMENTAL CONDITIONS ON THE DEVELOPMENT OF DISEASE SYMPTOMS CAUSED BY *PUCCINIA RECONDITA* ON WINTER WHEAT SEEDLINGS

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Abstract: The objective of the study was to determine the effect of leaf wetness period and air temperature on development of disease symptoms caused by *Puccinia recondita* on winter wheat. The experiments were carried out in growth chamber at the Institute of Plant Protection in Poznań. Seedlings of a susceptible winter wheat cultivar Mikon, were artificially inoculated with urediniospores of *P. recondita* and incubated in temperature of 15 and 20°C. The period of duration of leaf wetness varied from 2 to 14 hours. Disease symptoms on seedlings at 20°C appeared 7 days after inoculation. Reduction of temperature to 15°C resulted in the elongation of latency period to 8 days. The relationship between leaf wetness period and disease symptoms severity was also observed. The gratest number of urediniospores in both tested temperatures were observed on plants exposed to 14 hours of leaf wetness. In temperature of 20°C 4 hours of wetness duration was enough to guarantee infection and the appearance of *P. recondita* pustules, whereas in 15°C at least 10 hours of wet period was needed to cause disease symptoms development. The experimental results were used to produce two equations describing relation between leaf wetness and symptoms development in tested temperatures.

Key words: *Puccinia recondita*, winter wheat, leaf wetness, temperature

INTRODUCTION

Disease process iniciated by plant contact with a pathogen depends in a considerable degree on environmental conditions. An essential problem in explaining the role of environment in the interaction between plant and pathogen is to define the effect of meteorological parameters on the development of disease symptoms. Environmental factors determining plant infection by pathogens mainly include atmospheric precipitation, relative humidity and air temperature. Propagation spores of *Puccina*

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recondita f. sp. *tritici*, germinate in a wide range of temperatures (2–30°C) in the presence of water available at least for 3 hours. After the pathogen penetration into the plant, its development depends mainly on temperature (Eversmeyer 1972). Minimal values of temperature conditioning the development of mycelium and sporulation are 2 and 10°C respectively. On the other hand, the mentioned processes are completely inhibited when the temperature exceeds 35°C. However, the determination of effect of meteorological parameters on the development of pathogen cannot be confined to the determination of cardinal values of particular factors. It is known that the intensity of biological processes is subjected to changes depending on the values of parameters stimulating their course. Therefore, there is a need of studies aiming at the formulation of mathematical equations determining the relationships between the development of pathogen in the plant and conditions of environment. A confirmation of this view is supplied among others by the results of experiments referring to the interrelation between light and wheat infection by *P. striiformis* and *P. recondita* f. sp. *tritici* (Vallavielle-Pope et al. 2002) and experiments investigating the role of temperature and light in the germination process of urediniospores of *P. substriata* var. *indica* (Tapsoba 1997). The objective of this work was to determine the effect of the seedlings wheat leaf wetness duration and ambient temperature on the development of disease symptoms evoked by the fungus *P. recondita* f. sp. *tritici* in winter wheat.

MATERIALS AND METHODS

Experiments were carried out in controlled conditions, in a growth chamber, at 15 and 20°C and constant air humidity of 60%. Artificial light was provided by six 36 W Fluora Lamps for 16 hours a day. Studies consisted of artificial inoculation of winter wheat seedlings with spores of *P. recondita* f. sp. *tritici* and estimation of the development rate of evoked disease symptoms. Seeds of winter wheat cv. Mikon were sown into pots of 5 cm diameter. In each pot, 20 seeds were placed. After 10 days, when the plants reached the phase of 2nd leaf (BBCH – 12), they were artificially inoculated. For this purpose, water suspension of urediniospores was used and the plants were sprayed using an atomizer. After inoculation, the seedlings were put into airproof containers to maintain leaf wetness for optional time and exposed to a temperature of 15 or 20°C. After 2, 4, 5, 6, 10 and 14 hours, the plants were removed from the containers and transplanted from pots into test-tubes placing each plant into a separate test-tube. Three days after the transplantation, the plants were observed every day in order to record the number of pustules appearing on particular plants. Observations were carried out until the moment when no further increase of pustule number was noticed on the analysed plants. Observation results were entered into a calculation sheet and statistical calculations were carried out.

RESULTS

At the temperature of 15°C, on plants with leaves wetted for at least 10 hours, the first disease symptoms appeared on 8th day after inoculation and the maximal number of pustules was recorded after subsequent 8 days. On the remaining seedlings, disease symptoms did not occur (Table 1). Seedlings with leaves wetted for 14 hours after inoculation showed a greater number of pustules than leaves which were

Table 1. Number of pustules on winter wheat seedlings cv. Micon recorded on a day with maximal development of symptoms

Leaf wetness period [hours]	Temperature	
	15°C	20°C
2	0	0
4	0	6
5	0	22
6	0	80.75
10	5.5	85.25
14	13.75	103

kept in wet condition for 10 hours. Mathematical description of the effect of time length of leaf wetness on the number of pustules recorded on the day of maximal intensity of disease symptoms at 15°C is presented by the following equation (Fig. 1):

$$y = -0.0029x^3 + 0.1952x^2 - 1.3318x + 2.0297$$

(x = the number of hours when leaves were wetted; y = the number of pustules).

At the temperature of 20°C, on plants the leaves of which were in wet condition during a time interval not shorter than 4 hours, the first pustules appeared seven days after the date of artificial inoculation and their number was increasing during the successive 6 days (Table 1).

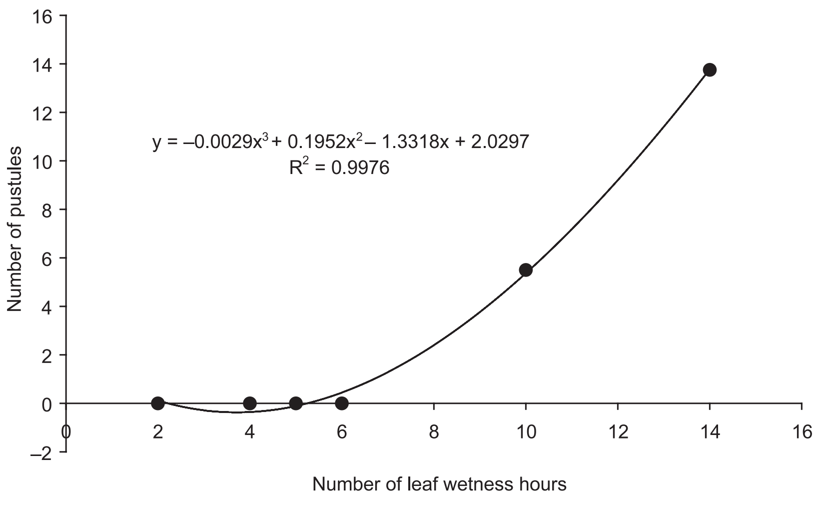

Fig. 1. Effect of leaf wetness period of winter wheat seedlings cv. Mikon on the number of *Puccinia recondita* f. sp. *tritici* pustules in 15°C

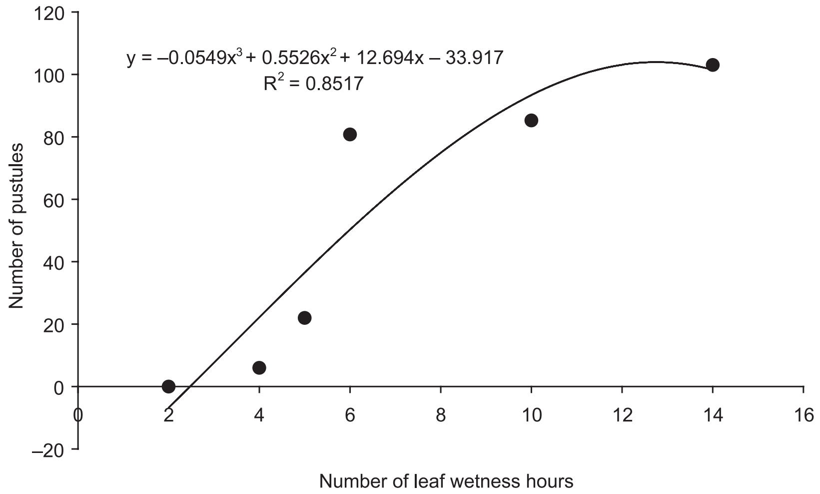

Fig. 2. Effect of leaf wetness period of winter wheat seedlings cv. Mikon on the number of *Puccinia recondita* f. sp. *tritici* pustules in 20°C

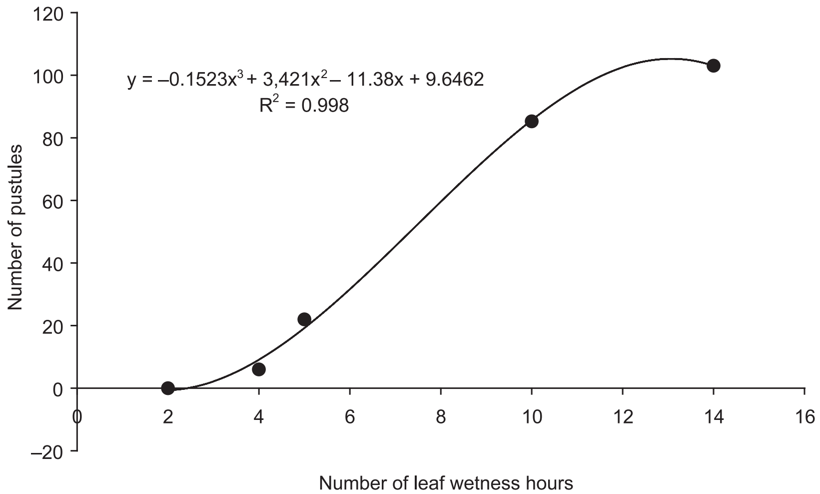

Fig. 3. Effect of leaf wetness on the number of *P. recondita* f. sp. *tritici* pustules in 20°C after removal of observation results obtained as the effect of 6-hour wetness after inoculation

On the other hand, there were no disease symptoms during the experiment on wheat seedlings maintained with wet leaves only for 2 hours. The greatest number of pustules was recorded on plants with leaves wetted for 14 hours. Shortening of the period of leaf wetness caused the decrease of pustule number. The interdependence between the number of pustules recorded on the day of the maximal intensity of disease symptoms and the number of leaf wetness hours after inoculation at 20°C was determined using the following equation (Fig. 2):

$$y = -0.0549x^3 + 0.5526x^2 + 12.694x - 33.917$$

(x = the number of hours with wetted leaves; y = the number of pustules).

On the other hand, the elimination of the observation results describing relation between pustule numbers and 6-hour wetness after inoculation, the adjustment of the model to the data was significantly improved and the dependence between the studied features was described by the following equation (Fig. 3):

$$y = -0.1523x^3 + 3.421x^2 - 11.38x + 9.6462$$

DISCUSSION

High values of the determination coefficient defining adaptation degree of the model to the data indicate a close relationship between leaf wetness and intensification of disease symptoms characteristic of wheat leaf rust. The obtained results are convergent with the results of studies by van Hees-Boakema and Zadoks (1986) who used Rubis cultivar in their studies on *P. recondita* urediniospore infectivity. In their experiment, the authors recorded no disease symptoms on wheat seedlings maintained with wet leaves for two hours after inoculation, and only found few pustules on leaves wetted for 4 hours at 18°C. On the other hand, intensive infection of seedlings occurred on leaves wetted for at least 6 hours. Furthermore, it was shown that the number of pustules found on 9th day after inoculation on plants wetted for 6 hours made about 60% of the total number recorded on leaves wetted for 12 hours after incoulation. In our own studies, the number of pustules recorded on seedlings kept with wet leaves for 6 hours made 78% of the total number recorded on leaves wetted for and 14 hours. The above difference may result from the reaction of plant cultivar to *P. recondita* infection. The thesis about significant relationship between genetic plant differentiation and the occurrence of disease symptoms evoked by wheat seedlings infected by *P. recondita* has been confirmed by the studies of Statler and Nordgaard (1980). On the basis of experimental artificial inoculation results of three wheat cultivarts by *P. recondita* carried out in controlled conditions, the authors found a significantly greater number of pustules in Thatcher cultivar as compared with Botno and Relette cultivars. Furthermore, the authors showed a differentiation in the number of pustules dependidng on the length of leaf wetness time on the analysed wheat cultivars which was confirmed by our results. Data presented by Statler and Nordgaard (1980) indicating a dependence between the time length of leaf wetness and the number of pustules shown on the diagram resemble a stretched letter 'S'. The relationship between variables can be described as a polynomian of the third degree for which the determination coefficient is 0.98. It corresponds with the study results of Vallavielle-Pope et al. (1995) who investigated the dependence between wheat leaf wetness time and the number of pustules and showed the obtained data in a similar form of the curve. It has been also confirmed by our experiments.

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POLISH SUMMARY

WPŁYW WARUNKÓW ŚRODOWISKOWYCH NA ROZWÓJ OBJAWÓW CHOROBOWYCH WYWOŁANYCH PORAŻENIEM PSZENICY OZIMEJ PRZEZ *PUCCINIA RECONDITA*

Celem pracy było określenie wpływu długości okresu zwilżenia liści i temperatury otoczenia na rozwój objawów chorobowych wywołanych przez grzyb *Puccinia recondita* f. sp. *tritici* na pszenicy ozimej. Eksperymenty prowadzono w komorze klimatycznej na terenie Instytutu Ochrony Roślin w Poznaniu. Siewki podatnej odmiany pszenicy ozimej Mikon były sztucznie zakażane zarodnikami grzyba *Puccinia recondita* f. sp. *tritici* i inkubowane w temperaturze 15 i 20°C. Okres zwilżenia liści wynosił 2–14 godzin. W temperaturze 20°C pierwsze objawy chorobowe, wywołane porażeniem roślin przez *Puccinia recondita* f. sp. *tritici*, stwierdzono po 7 dniach od daty przeprowadzenia sztucznej inokulacji. Obniżenie temperatury do 15°C spowodowało wydłużenie okresu latentnego do 8 dni. Zaobserwowano ponadto związek pomiędzy długością okresu zwilżenia liści, po przeprowadzonej inokulacji, a nasileniem występowania objawów chorobowych. Najwięcej urediniów w obu analizowanych temperaturach zaobserwowano na roślinach poddanych czternastogodzinnemu okresowi zwilżenia liści. Minimalny okres zwilżenia liści warunkujący wystąpienie objawów chorobowych był zależny od temperatury. W temperaturze 20°C, czterogodzinne zwilżenie liści gwarantowało skuteczną infekcję, warunkującą wystąpienie, po okresie inkubacji, objawów chorobowych. Natomiast w 15°C objawy chorobowe odnotowano na roślinach utrzymywanych w stanie zwilżenia przynajmniej przez dziesięć godzin. Na podstawie uzyskanych wyników opracowano dwa równania opisujące zależność pomiędzy długością okresu zwilżenia liści i nasileniem objawów chorobowych w analizowanych temperaturach.