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INFLUENCE OF TEMPERATURE AND DAYLIGHT LENGTH ON BARLEY INFECTION BY *PYRENOPHORA TERES*

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Abstract: Net blotch caused by *Pyrenophora teres* is the most important disease of barley in many regions in which this cereal is cultivated. In the performed work the influence of solarization period and temperature on infection of barley by *P. teres* was estimated. Three isolates of each *P. teres* f. *teres* and *P. teres* f. *maculata* were used. The response of six barley genotypes to the pathogen was estimated. Barley infection was differentiated and depended on solarization period, and the isolate of *P. teres*. Number of infected plants increased with the increase of temperature. Interaction occurred among length of solarization period and temperature. The highest barley infection by *P. teres* f. *teres* was observed at 10 hours of solarization and temperature 25°C.

Key words: *Drechslera, Pyrenophora teres*, net blotch

INTRODUCTION

Net blotch caused by *Pyrenophora teres* is the most important disease of barley in many regions in which this cereal species is cultivated. Depending on the type of disease symptoms are distinguished the net form caused by *P. teres* f. *teres*, manifested as dark-brown net spots, either with or without a chlorotic rim, or the spot form caused by *P. teres* f. *maculata* observed as dark-brown oval spots, polygonal irregular spots, either with or without a chlorotic rim. It is frequently difficult to reach a correct diagnosis of causal agents of spot symptoms, as they may be caused also by other biotic and abiotic factors. Moreover, the response of plants to *P. teres* depends on the development stage and barley cultivar as well as environmental conditions. Aim of this work was to determine the influence of temperature and solarization periods on barley infection by selected *P. teres* isolates.

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MATERIALS AND METHODS

Three isolates of *P. teres* f. *teres* and three isolates of *P. teres* f. *maculata*, coming from Denmark and Poland, were used in the experiment (Tab. 1). The response to the pathogen was assessed in 6 barley genotypes: Manchurian CI 739, Code 65, Aramir, CI 9820, Marocco and Rojo CI 5401. Three temperature ranges of 15°C, 20°C and 25°C, and 3 solarization periods of 10 h, 14 h and 18 h were used in the experiment. The source of light was an Osram L 36W/76 light bulb, 2.32 W/m^2. A pot experiment was conducted in 4 replications. A replication consisted of a ceramic pot of a diameter of 14 cm with 3 plants. Fourteen-day old plants at the stage of 2–3 leaves were infected with isolates of *P. teres* f. *teres* (Ptt) (D3/Dt, 56a NT, 62/2) and *P. teres* f. *maculata* (Ptm) (D1/Dm, D4/Dm, 37). Inoculum was prepared of 14-day old cultures grown on 50 ml glucose medium with yeast extract. After the culture was drained, the fungus was blended for approx. 2 min with an addition of 50 ml 0.1% Tween 20. Plants were inoculated by spraying with a suspension of conidia and mycelial fragments. After inoculation plants were covered with glass cylinders for 48 h. Seven days after inoculation the percentage of diseased leaf area was assessed on the most infected leaf blade. Results were analyzed statistically by ANOVA using Statistica software.

Table 1. Origin of *P. teres* isolates

Forms of *P. teres*	Isolate	Origin/plant
maculata	D1/Dm	Kopahnke D./-
	D4/Dm	Kopahnke D. (20:1)/-
	37	Poland/ winter barley
teres	D3/Dt	Kopahnke D. Re Am E. 1.3/-
	56aNT	Poland/spring barley
	62/2	Poland/spring barley

RESULTS

The percentage of infected barley leaf area depended on the isolate of *P. teres* and the applied solarization period (Tab. 2). An interaction was found between analyzed factors. On average for all isolates the highest percentage of infected leaf surface was recorded at 10 h solarization. In case of isolate D1/Dm (Ptm) barley infection at all day lengths turned out to be similar. In almost all isolates at 14 h and 18 h solarization infection rates were comparable, only isolate 56a NT infected barley more strongly at 18 h solarization than at 14 h solarization. When different temperatures were applied, similarly as in case of day length, the response of plants depended on the used isolate (Tab. 3). The highest infection rate was caused by isolate 56aNT (Ptt) at 25°C. Isolates D1/Dm (Ptm) and 62/2 (Ptt) infected plants to a similar degree at all applied temperatures. In turn, in case of the other isolates infection rates increased with the increase of temperature. On average for all isolates the highest percentage of leaf area infected with *P. teres* was recorded at 25°C. Only in case of isolates D1/Dm (Ptm) and

62/2 (Ptt) leaf infection turned out to be similar at all temperature ranges. Means for all isolates at 15 and 20°C turned out to be similar.

Table 2. The effect of day length on barley infection by *P. teres* (mean for three temperatures)

P. teres forms	Isolate	Percentage of infected leaf area			
		at day length [h]			means
		10	14	18	
maculata	37	13.3 de	4.1 gh	2.1 h	6.5 c
teres	D1/Dm	2.9 h	2.7 h	1.8 h	2.5 cd
	D4/Dm	22.3 c	10.5 efg	5.3 fgh	12.7 b
	56aNT	47.5 a	18.0 cd	31.3 b	32.3 a
	62/2	10.5 ef	3.8 gh	2.8 h	8.6 bc
	D3/Dt	20.7 c	3.7 h	4.4 fgh	5.7 c
Control		0 h	0 h	0 h	0.0 d
Mean		16.8 a	6.1b	6.8 b	–

Table 3. The effect of temperature on barley infection by *P. teres* (mean for three-day length)

P. teres forms	Isolate	Percentage of infected leaf area			
		at temperatures [°C]			means
		10	14	18	
maculata	37	3.4 ghi	3.2 ghi	12.9 de	6.5 c
teres	D1/Dm	2 hi	1.8 hi	3.6 ghi	2.5 cd
	D4/Dm	9.3 efg	11.2 def	17.6 cd	12.7 b
	56aNT	21.6 c	30.5 b	44.8 a	32.3 a
	62/2	5.3 fghi	4.7 fghi	7.1 efgh	8.6 bc
	D3/Dt	2.9 ghi	2.8 ghi	20.2 c	5.7 c
Control		0 i	0 i	0 i	0.0 d
Mean		6.3 b	7.7 b	15.2 a	–

In the conducted experiment an interaction was found between leaf infection by the forms of *P. teres* f. *teres*, period of solarization and temperature values. The highest infection was noted at the shortest solarization period (Fig. 1). Usually infection increased at higher temperatures (Fig. 2). Such a dependence was manifested most strongly at 10 h solarization and at 18 h solarization. Infection with isolates belonging to Ptt at these day lengths and temperatures of 20 and 25°C was higher than for isolates belonging to Ptm (Fig. 3). At 14 h solarization there was a complete lack of variation in plant infection depending on temperature and the type of used isolate.

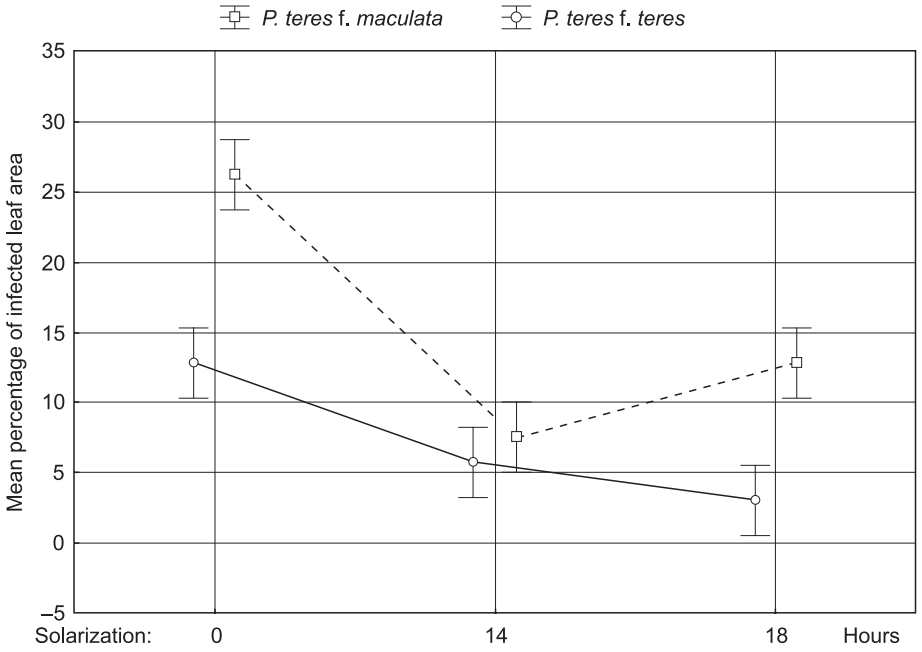

Fig. 1. The effect of day length on barley infection by *P. teres* f. *maculata* and *P. teres* f. *teres*

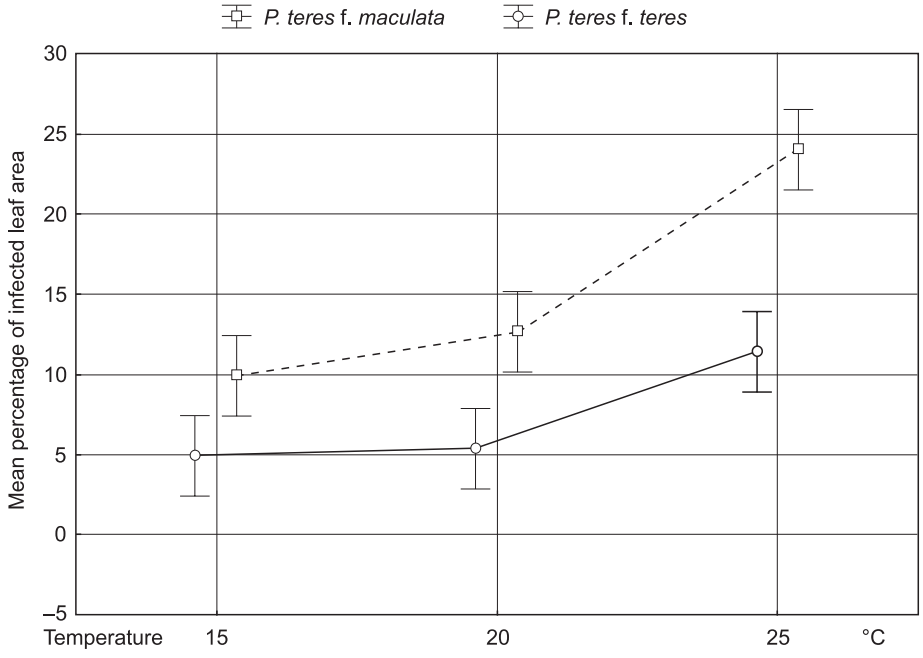

Fig. 2. The effect of temperature on barley infection by *P. teres* f. *maculata* and *P. teres* f. *teres*

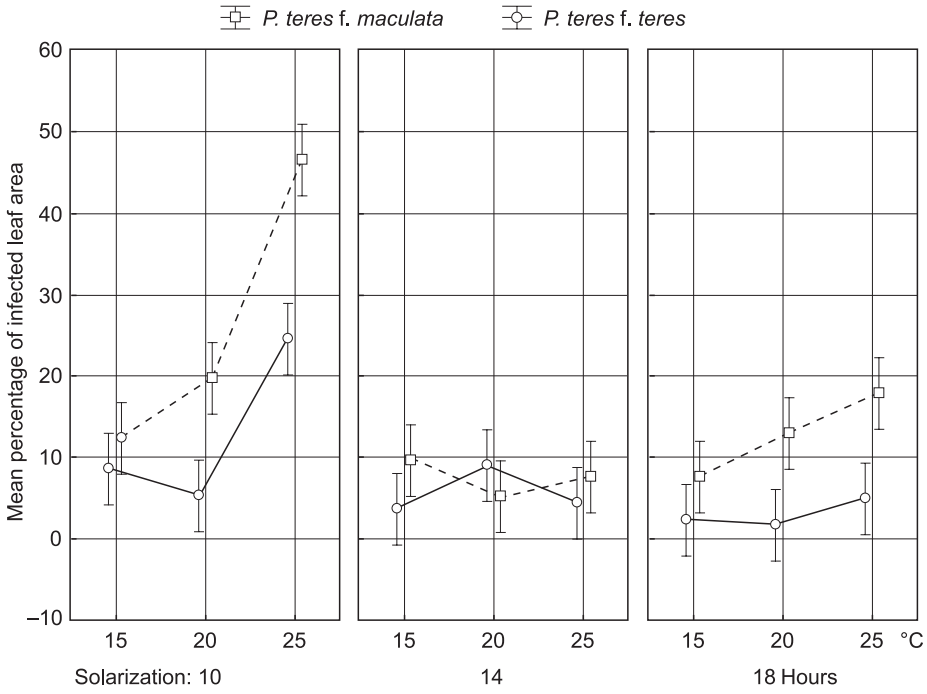

Fig. 3. The effect of temperature and day length on barley infection by *P. teres* f. *maculata* and *P. teres* f. *teres*

Table 4. Infection of barley cultivars by *Pyrenophora teres*

P. teres forms	Isolate	Percentage of infected leaf area						
		Manchurian CI739	Code 65	Aramir	CI9820	Marocco	Rojo CI5401	Means
maculata	37	2.9 hi	4 fghi	10.2 defghi	4.3 fghi	8.5 defghi	9 defghi	6.5 c
teres	D1/Dm	1.5 i	2.6 hi	4.8 fghi	1.4 i	2.3 hi	2.2 hi	2.5 cd
	D4/Dm	5.8 fghi	13.2 efgh	18.8 cd	6.8 efghi	14.4 cdefg	17.2 cde	12.7 b
	56aNT	12.1 defgh	24.6 c	42.5 ab	33.4 bc	37.9 b	43.0 a	32.3 a
	62/2	2.4 hi	9.8 defghi	15.3 cdef	3 hi	10.1 defghi	10.9 defghi	8.6 bc
	D3/Dt	1.1 i	2.6 hi	8.5 defghi	2.8 hi	6.5 efghi	12.8 defgh	5.7 c
Control		0 i	0 i	0 i	0 i	0 i	0i	0.0 d
Mean		3.7 c	8.1 b	14.3 a	7.4 bc	11.4 ab	13.6 a	-

Variation was found in infection between cultivars, with cv. Aramir, Rojo CI5401 and Marocco being infested most strongly, while cv. Manchurian was infected least strongly (Tab. 4). Differences were also observed in plant response to individual isolates, with isolate 56aNT (Ptt) causing the highest infection and D1/Dm (Ptm) causing the slightest infection. An interaction was also recorded between the applied isolate and barley cultivar. In case of isolate D1/Dm (Ptm) all cultivars responded similarly – with leaf infection ranging from 1.5 to 4.8%, with no statistically significant difference being found.

In turn, infection with isolate 56aNT (Ptt) ranged from 12.1 to 43.0 and differed significantly.

DISCUSSION

The highest barley infection by *P. teres* was observed at a short day. Such a situation may be connected with a lower resistance of barley plants to pathogen under those conditions. It is also possible that short day conditions are more advantageous than long day conditions for the development of *P. teres*. Barley as a long-day plant needs a long day to enter the generative phase. A faster growth of Ptt than Ptm isolates was observed *in vitro*. This increase was higher in the dark than at the alternating application of 12 h solarization and 12 h darkness (Kosiada, unpublished data). Other authors did not confirm varied growth of *P. teres* depending on solarization (Jánošová 1991). The highest infection of barley plants at a short day, as a result of inoculation with *P. teres*, occurred in case of most isolates except for D1/Dm. At the same time it needs to be stressed that this isolate exhibited low pathogenicity under all applied conditions. Although at 10 h and 18 h daylight there were differences in infection rates between fungal forms (Fig. 1), when analyzing individual isolates and not their affiliation to a specific form, it was found that isolates belonging to Ptm (37, D1/Dm) and those belonging to Ptt (62, D3/Dt) cause similar intensity of the disease.

When analyzing the effect of temperature, the highest infection was observed at 25°C (Fig. 2). It seems rather natural since the rate of biological processes, including Pt growth, increases with the increase in temperature. A temperature of 25°C does not exceed yet the optimum of pathogen development, while the optimum of disease development occurs at 25°C (Shipton *et al.* 1973). For the infection to develop it is necessary to maintain high humidity for 10–30 h or longer, depending on temperature of 8–33°C, with the optimum being 15–25°C (Mathre 1982).

Along with the increase in temperature the difference concerning infection with Ptt and Ptm increases, with that caused by Ptt being higher. At 20 and 25°C these differences were statistically significant. In spite of differences observed in infection at analyzed temperatures between pathogen forms, cases of similar infection caused by Ptm (37) and Ptt (D3/Dt) were also found.

At different temperatures and at different day lengths highly varied infection intensity was recorded, being the highest at 25°C and 10 h day. In case of a high infection rate more intense infection was reported for Ptt than for Ptm.

Considerable variation was found in studies on infection of barley cultivars with *P. teres*, which was also confirmed in numerous studies by other authors (Douiyssi 1998; Skurdenienė 2000). Resistance of the same barley cultivar to both fungal forms

varies, depending on the applied isolate (Tekauz and Mills 1974; Khan 1982; Tekauz 1990; Arabi *et al*. 1992; Graner *et al*. 1996).

In the study by Tekauz and Mills (1974) varied susceptibility of cultivars to isolates Ptt and Ptm was reported. Susceptibility of analyzed cultivars to Ptt was usually higher than that to Ptm (Scott 1991).

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POLISH SUMMARY

WPŁYW TEMPERATURY I DŁUGOŚCI DNIA NA PORAŻENIE JĘCZMIENIA PRZEZ *PYRENOPHORA TERES*

Plamistość siatkowa jest najważniejszą chorobą jęczmienia w wielu rejonach jego uprawy. W pracy oceniano wpływ długości oświetlenia i temperatury na porażenie roślin jęczmienia przez *Pyrenophora teres*. Do badań użyto po trzy izolaty *P. teres* forma *teres* oraz *P. teres* forma *maculata*. Reakcję na potogena oceniano u sześciu genotypów jęczmienia. Porażenie jęczmienia było zróżnicowane i zależało od długości oświetlenia oraz użytego izolatu *P. teres*. Porażenie roślin wzrastało wraz ze wzrostem temperatury. Wystąpiła interakcja pomiędzy wpływem długości oświetlenia a temperatury na porażenie. Najwyższe porażenie jęczmienia przez izolaty należące do *P. teres* f. *teres* zaobserwowano przy 10-godzinnym oświetleniu i temperaturze 25°C.