Importance and Pathogenic Variability of the Barley Net and Spot Type Net Blotch in North West and Central Highlands of Ethiopia

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Abstract

Relative importance of spot type net blotch caused by *Pyrenophora teres* f. sp. *maculata* under Ethiopian condition so far is not well known mainly because its symptoms are hardly distinguishable from that of the barley spot blotch caused by *Cochliobolus sativus*. A field survey was undertaken in North Shewa Zone (central Ethiopia) and South Gonder Zone (north-western Ethiopia) in the Amhara region during the 2001/2002 main crop season in order to determine the prevalence and occurrence level of spot and net type blotch diseases of barley caused by *Pyrenophora teres* (Sacc.). Leaf samples with spot blotch and 50 net type symptoms were collected from each field. Analysis of the 2,250 samples with spot blotch symptoms revealed that 1,821(80.9%) of the samples were associated with *P. teres* f. sp. *maculata*, 365 samples (16.2%) yielded *C. sativus*, and 2.9% by other *Helminthosporium* species. There was no significant morphological and cultural variation ($P<0.05$) among isolates of *P. teres* (Sacc.) causing the net and spot forms. Highly significant variation ($P<0.01$) was observed in mean disease ratings of 11 barley cultivars inoculated with the two types of isolates. Seven barley genotypes namely CI4929, CI5401, CI2750, CI7584, CI739 CI2235, and CI4407-1 were resistant to all 30 isolates of the two forms while three (CI9820, CI5791 and CI9819) were susceptible. The differential reaction with respect to all pathogen isolates tested indicated that isolates were distinct from each other, and most likely belong to different physiologic races of *P. teres*. Highly significant variation ($P<0.01$) in the degree of virulence was observed among isolates of each form of *P. teres*. This study revealed wide pathogenic variability of *P. teres* isolates in the study area that requires attention in resistance breeding program.

Key words: Barley, net blotch, pathogenic variability
Running title: Pathogenic variability of the barley net and spot type net blotch

Introduction

Barley (*Hordeum vulgare* L.) is a major cereal crop in the highlands of North Shewa, South Gonder, West Gojam and parts of Wollo (Asmare et al. 1998, Chilot et al. 1998). Despite its wide range of uses, the yield of barley is still very low. Diseases are among the constraints responsible for the poor productivity of the crop (Berhane et al. 1996). Barley net-blotch (*P. teres*) is a common disease throughout the major barley growing regions of Ethiopia (Yitbarek et al. 1996). It is an economically important disease that susceptible cultivars suffer from yield loss of up to 34 % (Yitbarek et al. 1996).

In many parts of the world *P. teres* exists in two forms: *P. teres* f. sp. *teres* causing the net type and *P. teres* f. sp. *maculata* causing the spot type (Smedegaard-Petersen 1977b, Tekauz 1990). The conidia and hyphal cells of *P. teres* are multinucleate; this heterokaryotic characteristic was considered first as a possible source of variability and unstability of the lesion types (Shipton et al., 1973). However, the ability to produce net versus spot type symptoms is

conditioned by two independently segregating genes (Smedegard-Petersen 1977a). Therefore, the lesion types incited by individual isolates depend on genetic characters.

The spot type is not yet well known under Ethiopian conditions, as the symptoms are not easily distinguishable from the spot blotch caused by *C. sativus*. As a result, either the net blotch problem might have been undermined because spot type was not taken into consideration, or the spot blotch exaggerated since the spot type might be included during disease assessment. This paper describes the relative importance of the net and spot forms of net-blotch and the pathogenic variation among isolates of *P. teres* causing the two forms of the disease in North Shewa and South Gonder Zones in Amhara Region.

Materials and Methods

The survey of barley blotches was undertaken in North Shewa (central Ethiopia) and South Gonder (north-western Ethiopia) Zones during the 2001/2002 main cropping season. These two zones represent major barley growing areas, with an altitude 2600 – 3100 m. Three woredas (Angolelana Asagert, Debre Birhan Zuria and Lai Gayint) were selected for the study. From each woreda, fifteen barley fields in each of three priory selected Peasant Associations (PA) were sampled at random giving a total of 45 barley fields. Disease assessment was performed on 100 plants that were randomly selected by moving diagonally across the field. This was carried out at the milky-ripe growth stage of the plant. Disease severity was recorded on a 1–10 scale as described by Tekauz (1985). From each PA, 250 leaf samples with spot blotch symptoms and 50 leaf samples with net type symptoms were collected and allowed to air dry and then stored in a refrigerator. The 2250 leaf samples with spot blotch symptoms were examined microscopically to characterize the conidia and to determine the frequency of *P. teres* f. sp. *maculata* and *C. sativus*. Then, the pathogens were identified using standard laboratory techniques. Isolates found to be *P. teres* f. sp. *maculata* were saved. Fifteen spot type and fifteen net type isolates from all woredas were selected based on sporulation capability.

Morphological and cultural characteristics of isolates

Colonies of each isolate were first allowed to grow on petridishes that contained PDA. Then a 5 mm disc from the periphery and actively growing hyphae was cut and placed at the middle of a petridish with PDA. The experiment was replicated three times in completely randomized design. Spore counts were made and the colony diameter (radial growth) was measured on alternate days up to three weeks after incubation. Moreover, the colony colour (Munsel Soil Color Chart), colony shape, shape of the periphery and surface of the colony, conidial width and length, the number of septa and shape of spores were recorded.

Virulence of isolates

Isolates of the two types of net blotch were evaluated for the variation in virulence on barley differential genotypes (CI 2750, CI 2235, CI 540-1, CI 9820 CI 9819, CI 5791, CI 7584, CI 739 and CI 4407-1 CI 4929). The susceptible check for net blotch, Bedi-black was also included. These differential genotypes were suggested by Steffenson and Webster (1992) to be used as a standard series for evaluating the virulence of *P. teres* populations.

Seven seeds of each genotype were planted on a 7 cm diameter plastic pot that

contained sterilized soil-sand mixture (2:1). After emergence seedlings were thinned to five seedlings per pot; they were then fertilized to obtain vigorous growth. The pots were placed in a glass house. They were arranged in a factorial arrangement in completely randomized block design in three orders, woreda, spot and net forms with three replications. Pure cultures of each isolate were produced on PDA or V-8® juice agar plates and subjected near UV light for sporulation. Each plate with a sporulating growth of the isolates was flooded with sterile distilled water and scraped to harvest conidia. The suspension was homogenized and the concentration of spores was adjusted to 2 x 10^4 conidia/ml. Inoculation of barley seedlings was made at the second leaf stage using a hand sprayer driven by compressed air; pots were then placed in a growth chamber that was adjusted to a relative humidity of 100% and tempreature of 15–20 ^{0}C. Inoculated plants were observed daily for development of disease symptoms and ratings were made 7–10 days after inoculation until three months with ten days interval. Isolates which have an average rating higher than 4.3 were considered as highly virulent, whereas isolates with a rating less than 4.3 were considered as less virulent. Isolates of *P. teres* were grouped into pathotypes on the basis of their similarity in virulent phenotype on the differential genotypes. The data collected were subjected to ANOVA using the MSTAT-C program.

Results

Distribution, incidence and severity of net blotch

Varying levels of disease incidence and severity were observed on the landraces and among localities. As a result, despite differences in genotypes and environments the mean incidence and severity of net type of net blotch was 82–100% and its mean severity was 26–44% (Table 1).

The microscopic examination showed that the conidia of *C. sativus* were slightly curved to straight with smooth walls, fusiform to broadly ellipsoidal, olive brown, oblong, tapered toward the end, and had a prominent basal scar, with three to four septa. However, the conidia of *P. teres* f. sp. *maculata* were straight, cylindrical, rounded at the ends, sub hyaline to straw-colored, and three to four pseudo-septate. The majority of the leaf samples with spot blotch symptoms i.e. 1,821 leaf samples (80.9%) were affected by net blotch caused by the fungus *P. teres* f. sp. *maculata*, the remaining 365 samples (16.2%) were infected by *C. sativus*. Other *Helminthosporium* spp. occurred in 64 leaf samples (2.9%) (Table 1)

The percentage of infection of *P. teres* f. sp. *maculata* was almost similar in samples from North Shewa woredas, while it was comparatively high is Lay Gayint woreda South Gondor. The distribution of the spot form of *P. teres* was higher than the distribution of the spot blotch caused by *C. sativus* (Table 1). Although both forms of *P. teres* occurred in all woredas, *P. teres* f. sp. *teres* was predominant.`

Based on visual assessments, the incidence of spot blotch caused by *C. sativus* was high while net blotch was low in Lay Gayint. However, laboratory results showed that the percentage of incidence of net blotch was high (Table 1).

Table 1. Frequency of *P. teres* f. sp. *maculata* and other pathogens in leaf samples with spot blotch symptoms from nine Peasant Associations

Woreda	Peasant Association	Pathogen identified [a]		Other *Helminthosporium* spp.
		P.teres f.sp.*maculata*	*C. sativus*	
Angolelana Asagert	Wontu	200 (80) [b]	44 (17.6) [b]	6 (2.4) [b]
	Kotu	187 (74.8)	55 (22)	8 (3.2)
	Chacha	185 (74)	56 (22.4)	9 (3.6)
Average		(76.3)	(20.7)	(3.1)
Debre Birhan Zuria	Bakelo	191 (76.4)	49 (19.6)	10 (4.0)
	Atakelt	190 (76)	52 (20.8)	8 (3.2)
	Keyite	215 (86)	30 (12)	5 (2.0)
Average		(79.5)	(17.5)	(3.1)
Lay Gayint	Wuhamedhen	227 (90.8)	16 (6.4)	7 (2.8)
	Gobgob	220 (88)	25 (10)	5 (2.0)
	Salea	206 (82.4)	38 (15.2)	6(2.4)
Average		(87.1)	(10.5)	(2.4)
Total average		(80.9)	(16.2)	(2.9)

250 leaf samples for each peasant association
Figures in parenthesis are percentages for the respective diseases.

Morphology and cultural characteristics of the isolates

All isolates tested produced conidia on either PDA or V-8® juice agar but abundantly on PDA. Conidia were cylindrical in shape, hyaline in cold had three to four septa and mean length of 48–54 x 15–19μm for the net type and 47–56 x 18–19 μm for the spot type isolates. Significant difference ($P>0.05$) were not observed in width as well as length of the conidia among the two type isolates. However, mean values were numerically different and indicated a potential variability among the isolates of *P. teres* f. sp. *teres* and *P. teres* f. sp. *maculata*.

Significant differences ($P<0.05$) were obtained in radial diameters of colonies only after seven days of incubation among the net type isolates. Isolate 7 and 11 produced the largest colony; whereas, isolate 4 had the smallest colony diameter (Table 2). For isolates of the spot type, significant variation in colony diameter was observed after seven, fourteen and twenty-one days of incubation. Isolate number 18, 22 and 26 had comparatively the largest and isolate 28 the smallest colony (Table 3). Colony color of isolates for both the net and spot type on PDA ranged from gray to dark greenish gray, while most isolates showed dark greenish gray.

Colonies of all isolates were felty to woolly with well-defined zonation, except those of isolate number 9 of the net type and numbers 20, 21, 23 and 26 of the spot type that were tufted with faint zonation. The color of colonies from the bottom of the medium ranged from bluish black to black. The colony shape of the periphery was circular for both spot and net type isolates of *P. teres*.

Table 2. Radial growth of 15 isolates of *P. teres* f. sp. *teres* on potato Dextrose Agar (mm)

Isolate no	7 days		14 days		21 days	
	Mean	Range	Mean [NS]	Range	Mean [NS]	Range
1	64.3 abc [Z]	60–70	76.3 [Z]	71–86	83.3 [Z]	82–90
2	52.7c	42–62	67	56–77	81	84–80
3	52c	41–63	66.7	53–79	76.7	64–86
4	51.7 c	40–62	65.7	52–79	76	68–84
5	68 abc	62–72	79.7	71–88	86.3	79–90
6	53.3 bc	42–63	66	55–75	78	68–86
7	74a	72–76	86.7	84–88	92	92
8	65.7 abc	52–73	79.7	65–88	85.3	74–92
9	59 abc	51–72	71	64–81	84	78–90
10	57 abc	43–65	70.3	55–78	80.7	70–88
11	72.7a	73–75	85.3	80–88	92	92
12	61.3 abc	51–72	74.7	62–88	83.7	75–92
13	65 abc	60–73	74.7	71–82	78	61–88
14	70.3 ab	73–74	84.7	78–88	90.7	88–92
15	54.3 bc	50–62	65.3	61–73	78	76–80

[Z] Mean of three replications of each isolate
[NS]: Non significant
Values with the same letter in a column are not significantly different

Table 3 Radial growth of 15 isolates of *P. teres* f. sp. *maculata* on potato dextrose agar

Isolate no	7 days		14 days		21 days	
	Mean [Z]	Range	Mean	Range	Mean	Range
16	45 cd	40–52	57.7 cd	51–67	70.3 cd	65–78
17	49 bcd	43–52	61.3 bcd	58–64	78 abcd	76–80
18	74.3a	73–75	88a	88	92.3a	92–93
19	58.3 abcd	61–52	71.3 abcd	66–78	82.3 abc	75–90
20	67.7 ab	53–76	81.3 ab	68–78	89.3a	84–92
21	73.3 a	72–75	88a	88	90a	86–92
22	69 ab	60–74	82.3 ab	71–88	92a	82–92
23	65 ab	60–72	79 ab	71–88	87.3 ab	82–92
24	64.7 abc	60–71	77 abc	72–83	85.3 abc	82–90
25	64 abcd	60–71	74.7 abcd	72–80	86.7 abc	85–88
26	74a	73–75	88a	88	92a	92
27	55.7 abcd	51–64	66.7 abcd	60–78	80 abc	78–82
28	44.3 d	24–74	55.3 d	38–88	63.7d	45–92
29	55 abcd	31–73	65.3 bcd	42–84	71 bcd	50–88
30	70 a	72–74	82 ab	78–88	87.3 ab	84–92

[Z] Mean of three replications of each isolate
Values with the same letter in a column are not significantly different

Variation in pathogenicity among *P. teres* isolates

Disease symptoms first appeared 5 days after inoculation and the duration varied depending on the genotype. The net-type isolates produced brown to dark-brown colored blotch surrounded by a chlorotic zone with varying width on the leaf blade, with a net-like pattern. The spot-type isolates produced spot-like lesion on the test genotypes. All isolates of *P. teres* f. sp. *teres* and *P. teres* f. sp. *maculata* produced disease symptoms on the susceptible check, Bedi black, with respective severity of 2.6–8.0 and 2.0–9.0(Tables 4 and 5). This indicated that the experimental

environment was conducive for disease development.

Virulence and aggressiveness of a pathogen was determined by comparing the number of host genotypes on which isolates produced symptoms. Thus, the variability of the isolates (within and between forms) showed highly significant variation ($P<0.01$) among *P. teres* f. sp. *teres* isolates in disease severity on eleven barley genotypes, leading to the identification of different levels of virulence. As a result, isolates 2, 3, 14, and 15 produced susceptible type lesions on genotypes CI 9820, CI 5791, CI 9819 and Bedi black. The remaining eleven isolates were pathogenic to a varying range of genotypes. Based on the number of genotypes susceptible to an isolate, isolates 2, 3, 14 and 15, were identified as the most virulent, whereas, isolates 7 and 12 were identified as the least virulent (Table 4).

Similarly, the spot type (*P. teres* f.sp. *maculata*) isolates showed highly significant variation ($P<0.01$) in causing disease severity on the differential lines. As a result, isolate 27 produced susceptible type lesions on genotypes CI 9820, CI 5791, CI 9819 and Bedi black. Based on the number of genotypes susceptible to an isolate, isolate 27 was classified as the most virulent, whereas, isolates 18, 29 and 30 were classified as the least virulent (Table 5).

Highly significant variation ($P<0.01$) was observed in the mean disease ratings of the eleven barley cultivars inoculated with the net and spot type isolates of *P. teres* (Tables 4 & 5). None of the cultivars tested was highly resistant to all isolates, but genotypes CI 4929, CI 5401, CI 2750, CI 7584, CI 739 CI 2235, and CI 4407-1 were resistant to all isolates. Genotypes CI 9820, CI 5791, and CI 9819 were susceptible to all isolates similar to the susceptible check, Bedi black

The results of the experiment on the variability of *P. teres* indicated the presence of virulence variation in the pathogen popuation. Accordingly, isolates of *P. teres* f. sp. *teres* can be classified into five pathotypes and that of *P. teres* f. sp. *maculata* into four pathotypes. The genetic variability of the host genotypes accounts for the virulence variability of the barley net blotch pathogens because they obviously have different resistance genes against net blotch.

Pathotype 5 of *P. teres* f. sp. *teres* was comparatively, the most complex of all others because it overcame the resistance of three out of the ten tested differentials (Table 6). Though pathotype 3 and 2 were pathogenic on one genotype only, pathotype 3 was more pathogenic than pathotype 2 because the susceptible genotype CI 9819 has more or other resistance genes than CI 9820 has (Steffenson and Webster, 1992). With regard to *P. teres* f. sp. *maculata*, pathotype 4 was the most virulent of all the others because it would attack three out of the ten differentials (Table 6)

Table 4 Mean disease severity ratings of 15 isolates of *P. teres* f. sp. *teres* on ten barley differentials and one susceptible check

Isolates	Barley differentials										Check
	CI 739	CI 4929	CI 5401	CI 2750	CI 98 20	CI 7584	CI 2235	CI 4407-1	CI 5791	CI 9819	Bedi Black
1	0[z]	1.3	1.3	1.7	3.7	2.7	2.3	1.7	3.0	5.0	5.7
2	1.2	0.0	0.7	1.7	4.7	0.7	1.0	1.3	5.0	6.3	6.3
3	0.0	0.3	1.0	0.7	7.7	0.7	1.3	0.0	4.7	7.0	7.0
4	1.0	0.0	1.7	0.3	5.7	0.7	1.0	0.3	7.3	4.0	8.0
5	1.0	0.7	0.3	0.7	4.7	1.3	1.3	1.0	3.7	7.0	5.0
6	0.7	1.0	0.3	0.0	4.0	0.7	2.0	0.3	5.0	7.3	7.7
7	0.3	0.3	0.3	0.3	3.0	2.0	0.7	1.0	1.0	1.7	2.6
8	1.3	0.0	0.0	1.3	2.0	1.3	1.3	0.0	0.7	3.0	5.0
9	1.0	1.3	0.7	0.3	4.3	0.7	1.0	0.0	1.0	2.0	4.7
10	1.0	0.7	1.7	0.7	4.3	1.3	1.0	0.3	2.0	2.7	3.0
11	1.3	0.3	0.3	0.3	5.3	1.3	1.0	1.0	0.3	1.7	4.3
12	1.0	0.3	0.7	1.7	1.7	1.0	1.0	1.0	2.0	1.7	2.6
13	0.7	0.7	0.7	0.0	3.0	1.0	2.7	1.0	5.0	4.3	8.0
14	0.3	1.0	1.0	1.3	7.3	2.3	0.7	0.7	5.3	5.3	8.0
15	2.0	1.3	1.7	1.3	6.3	1.0	2.0	1.0	6.0	6.0	8.0
Mean[x]	**1.7 c**	**1.5 c**	**1.7 c**	**1.6 c**	**4.5 ab**	**1.2 c**	**1.4 c**	**1.6 c**	**3.5 b**	**4.3 ab**	**5.6 a**

[z] Disease severity rating based on a 1–10 scale as described by Tekauz (1985)
Ratings of 1-4.3 are classified as resistant and >4.3 as susceptible.
[x] Values are means of three replications of each genotype inoculated with all isolates of the respective pathogen, based on a 1-10 scale as described by Tekauz (1985)
Means followed by the same letters are not significantly different according to DMRT at $P \leq 0.01$

Table 5 Mean disease severity ratings of 15 isolates of *P. teres* f. sp. *maculata* on ten barley differentials and one susceptible check

Isolate	Barley differentials										Susceptible check
	CI 739	CI 4929	CI 5401	CI 2750	CI 98 20	CI 7584	CI 2235	CI 4407-1	CI 5791	CI 9819	Bedi Black
16	0.7 [z]	0.7	0.3	1.3	4.7	1.0	1.0	0.3	1.0	6.3	7.7
17	0.3	0.3	0.0	1.7	3.3	0.3	0.6	1.3	0.7	4.7	5.0
18	1.3	2.0	2.0	0.3	3.0	2.0	1.7	1.0	2.3	1.3	2.0
19	1.3	1.7	0.7	2.0	1.7	1.0	0.0	0.3	1.0	6.3	3.7
20	0.7	2.0	1.0	0.0	3.7	1.7	1.7	1.0	5.0	2.0	4.0
21	1.0	1.0	1.0	1.3	3.0	2.3	1.7	1.0	1.7	1.7	2.3
22	3.7	2.0	1.3	1.7	7.0	0.7	1.3	0.0	2.0	5.3	7.3
23	1.0	0.3	0.7	2.0	3.0	1.7	1.7	0.3	4.3	6.0	6.3
24	1.3	1.0	1.0	1.3	5.0	0.7	2.0	0.7	5.7	2.3	6.0
25	1.3	1.7	1.3	0.0	6.0	0.7	1.3	0.0	3.0	4.3	5.0
26	0.0	0.0	0.0	0.3	6.7	1.3	1.0	0.0	2.0	6.3	7.7
27	2.7	0.3	2.0	0.0	7.0	0.3	0.3	0.3	7.3	8.7	9.0
28	1.0	0.3	2.0	1.0	2.0	1.7	3.7	1.0	7.3	1.3	3.0
29	0.0	0.0	0.3	1.3	1.0	0.0	0.3	0.3	0.3	1.0	2.0
30	0.7	0.7	0.7	1.0	1.7	1.3	1.0	0.7	1.0	1.7	2.6
Mean [x]	**1.2 c**	**1.8 c**	**1.2 c**	**1.8 c**	**3.9 ab**	**1.1 c**	**1.3 c**	**1.5 c**	**3.5 bc**	**4.8ab**	**4.8 a**

[z] Disease severity rating based on a 1–10 scale as described by Tekauz (1985)
Ratings of 1–4.3 are classified as resistant and >4.3 as susceptible.
[x] Values are means of three replications of each genotype inoculated with all isolates of the respective pathogen, based on a 1–10 scale as described by Tekauz (1985)
Means followed by the same letters are not significantly different according to DMRT at $P \leq 0.0$

Table 6. Category of pathotypes of *P. teres* f. sp. *teres* and *P. teres* f. sp. *maculata*

Pathotype	Isolate numbers (f. sp. *teres*)	Susceptible genotypes	Isolate numbers (f. sp. *maculata*)	Susceptible genotypes
1	7,8,12	0	18,21,29,30	0
2	9,10,11	CI 9820	17,19,20,22,28	CI 9820
3	1	CI 9819	16,23,24,25,26	CI 5791, CI 9819
4	13	CI 5791, CI 9819	27	CI 9820, CI 5791, CI 9819
5	2,3,4,5,6,14,15	CI 9820, CI 5791, CI 9819	-	-

Discussion

Barley is affected a number of leaf spot diseases. The three *Helminthosporium* disease complexes spot blotch, net blotch and stripe diseases caused by *C. sativus*, *P. teres* and *P. graminea,* are common in Ethiopia (Yitbarek *et al.*, 1996). Elsewhere, it is well known that the pathogen *P. teres* occurs in two forms, *P. teres* f. sp. *teres*, which produces net blotch symptoms and *P. teres* f. sp. *maculata,* which produces spot blotch. However, the leaf spot caused by *P. teres* f. sp. *maculata* might be most easily confused with spot blotch caused by *C. sativus* (Smedegaard-Petersen 1977b, Tekauz 1990).

The spot type *P. teres* has not so far been known from Ethiopia. This study was an attempt to look into the extent and distribution of *P. teres* in its two forms in the Amhara Region. Furthermore, attempts were made to investigate the variability in pathogenecity of the *P. teres* f. sp. *teres* and *P. teres* f. sp. *maculata* isolates collected from the three woredas namely Angolela, Asagert, Debre Birhan Zuria in North Shewa and Lay Gayinta South Gonder Zones.

The color, shape and width of the conidia were in agreement with what Louw *et al.* (1995) reported. However, in the present study, length of the conidia 48–54 µm for net type, 47–56 µm for spot type was smaller than the values in the previous report which is versus 60-120 µm. Shipton *et al.* (1973) have found Conidia of *P. teres* with 1–10 septa, higher than the Conidia of *P. teres* identified by the present study. The conidial dimensions of *Pyrenophora* spp. could be affected by incubation condition (humidity and temperature).

The cultural characteristics of 30 isolates of *P. teres* in this study were similar to those reported by others (Smedegaard-Petersen 1971). Though some of the isolates had a significantly higher colony diameter than others, it was not possible to relate cultural characteristics of the isolates in any specific group to virulence or aggressiveness.

Numerous reports document the interactions that occur between *P. teres* isolates and various barley genotypes (Smedegaard-Petersen 1971, Tekauz 1990). Barley differentials showed a reafia ranging highly resistant to highly susceptible to this pathogen, and pathotype diversity exists within *P. teres*. In this study, the reaction of inoculated leaves ranged from resistant to susceptible to both forms of *P. teres* Symptoms produced by *P. teres* f. sp. *maculata* on barley leaves were confirmed as elliptical, fusiform, or irregularly shaped necrotic lesions, and that *P. teres* f. sp. *teres* yielded lesion characterized by dark-brown blotch with a net-like pattern where the lesions are accompanied by chlorosis.

The differential reaction of genotypes with varying degree of virulence with respect to all pathogen isolates tested indicated that all 30 isolates were distinct from each other, and were most probably different physiologic races of *P. teres*—supporting previous reports on the variability of *P. teres* pathogenic to barley (Smedegaard-Petersen 1971). The Ethiopian genotype CI 5791 still known worldwide as a good source of resistance to the disease (Arabi *et al.*, 1990) was observed susceptible to the two types of *P. teres*. However, Tekauz (1990) reported that this genotype is susceptible for the spot type but resistant to the net type of *P. teres*. In this study the resistance of CI 5791 was overcome by 12 isolates of both types. Yitbarek (2000) reported that five out of the eight isolates of *P. teres* evaluated were virulent on this host genotype. The susceptibility of this genotype for the net type in this study might have been due to the change in physiologic races of the *P. teres* population.

Studies on naturally occurring variability in a pathogen population are undertaken to understand the virulence and the host-plant interaction. These studies are a useful tool in order to identify valuable plant germplasm that can be used in the development of disease resistant cultivars.

Considering the high variability among isolates of *P. teres* found in this study, barley-breeding programs should concentrate on non-specific types of resistance as well. Proper knowledge of the virulence spectrum of the pathogen and of the sources of host resistance helps to achieve non-specific types of resistance (Tekauz, 1990). Of the 11 barley genotypes tested in this study, CI 4929 and CI 4407-1 are recommended crossing in the barley for breeding work; since they are assumed to exhibit non-specific resistance for they were least affected by all isolates. Moreover, the genotypes on which all isolates were avirulent (CI 4929, CI 5401, CI 2750, CI 7584, and CI 4907-1) can be additions sources of resistance in barley breeding program.

Results of this study showed that *P. teres* f. sp. *maculata*, the spot form of *P. teres*, is also important in the two barley-growing zones that were surveyed. Disease assessment made earlier as spot blotch might have been overestimated and future visual observation shall be supported by laboratory analysis to avoid assessing the spot form of net blotch as spot blotch. Therefore, researchers and development agents should give attention to this form of net blotch during assessment of foliar diseases of barley.

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