A Phytopathometric Response of Barley IMAGIC Populations Against Spot Form Net Blotch, *Pyrenophora teres* f. *maculata* Under Natural Epiphytotic Conditions in North Gondar, Ethiopia

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Abstract

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Spot forming net blotch disease caused by *Pyrenophora teres* f. *maculata* is a major disease of barley and causes a significant yield loss under favourable conditions in cool and moist areas. A set of 500 barley interconnected multi-parent advanced generation intercross lines were evaluated using an alpha lattice design for spot forming net blotch resistance under natural epiphytotic conditions along with sixteen parental lines at Dabat research field of Gondar Agricultural Research Center, Gonadar, Ethiopia, for two consecutive years (2022-2023). Disease severity was visually assessed using a 1-9 scale. Analysis of variance showed significant variation in the area under disease progress curve (AUDPC) of the studied lines. Disease epidemic progress was markedly lower in the 2023 cropping season (606.2%-days) compared to 2022 (1553.5%-days). Seventeen recombinant inbred lines (RILs) that showed consistent moderate resistance across both years were: 18, 19, 48, 82, 176, 180, 216, 254, 345, 404, 429, 432, 440, 468, 478, 491, and 511. Their ability to maintain moderate resistance under varying conditions suggested that they were strong candidates for further evaluation and potential inclusion in breeding programs aimed at enhancing disease resistance.

Keywords: Barley, Interconnected multi parent advanced generation inter cross lines, spot form net blotch, area under disease progress curve, resistance.

Introduction

Barley, *Hordeum vulgare* L. is a crucial staple food crop in Ethiopia's highlands, where it thrives under cool-season conditions and diverse agro-climatic regions. Ethiopia barley production of 2.45 million Metric Tons, represents 1.7% of global production (FAOSTAT, 2023). Barley productivity is low (2.5 t/ha) in Ethiopia as compared to world average of 3.05 t/ha and the reduction in productivity of the crop is mainly due to abiotic and biotic stresses.

In Ethiopia, barley faces significant threats from various plant pathogens, with net blotch, *Pyrenophora teres* being particularly damaging and economically important (Kiros *et al*., 2004; Meki & Tekalign, 2004). Traditionally attributed to *Pyrenophora teres* (formerly *Helminthosporium teres* Sacc.), recent research by Asnakech *et al*. (2005) has identified two distinct forms of the fungus: the net type caused by *P. teres* f. sp. *teres* and the spot type caused by *P. teres* f. sp. *maculata*. The spot type is characterized by dark brown, circular or elliptical spots with chlorosis on surrounding leaf tissues (Gupta & Loughman, 2001; Jayasena *et al*., 2002).

Yield losses from net blotch in Ethiopia can range from 12 to 41% (Terefe, 1990). Similarly, yield losses of 4 to 44% were reported for spot form of net blotch (SFNB) (McLean *et al*., 2016). Sayoud *et al.* (1999) reported an average loss of 40% of the annual value of the barley crop in North Africa, including Algeria, Tunisia, and Morocco. These losses are influenced by environmental factors, stubble management, crop rotations, and fungicide application (McLean *et al*., 2009; Turkington *et al*., 2011).

Ethiopian barley landraces are thought to have unique genes and allelic combinations that would be used in modern barley breeding programs to provide resistance to different pathogens (Adhikari *et al*., 2019) and has been used internationally as a source of useful genes for disease resistance. Ethiopian lines have been reported as sources of net blotch resistance in numerous previous studies (Manninen *et al.*, 2006; O'Boyle *et al.,* 2011).

In order to utilise this resource, plant breeders need sustainable new sources of resistance against diseases and an efficient use of such genetic resources. However, majority of the collected and crossed barley materials are not yet characterized in detail for their genetic diversity for spot form net blotch resistance (Yitbarek *et al*., 1996) and information on phenotypic variation of barley materials, which are essential in developing varieties resistant to the spot form net blotch causing pathogen, *P. teres* f. maculata, is lacking. Such information is crucial to the utilization, conservation and identification of landraces with potential to be exploited by barley breeders. The present experiment is designed to assess phenotypic variation for spot form net blotch resistance in barley lines under natural epiphytotic conditions in North Gondar, Ethiopia.

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Materials and Methods

Description of the experimental site

The experiment was conducted at Dabat in Gondar Agricultural Research site, located at 12.93178N and 37.74412 E, at an altitude of 2628 meter above sea level.

Plant materials used

The genetic background for this study included barley accessions derived from a cross involving sixteen parental lines, as described in Table 1. These were developed using the interconnected multiparent advanced generation Inter Cross (IMAGIC) method at the Sirinka Agricultural Research Center, with the HB1307 parental line serving as the interconnected line among the fifteen other parental lines. From this setup, five funnels were developed, each resulting in the selection of one hundred populations, leading to a total of 500 IMAGIC populations alongside the sixteen parental lines (comprising 163 two-rowed and 353 six-rowed barleys). The experiment also included HB42 and Miscal-21 as standard checks, and cv. Sabini was used as a susceptible check.

Experimental design and agronomic practices

To assess pathometric variability, barley lines were planted at one site using an alpha lattice design in the 2022 and 2023 cropping seasons, focusing on blotch spot area at Dabat location. The experimental layout included seven blocks, each consisting of seven plots and eleven sub plots. Each plot comprised two rows, each 2 meters long, with a spacing of 0.25 meters between rows. Fertilization was managed with NPS and urea, applied at rates of 121 kg/ha (all at planting) and 100 kg/ha (split application), respectively. A seed rate of 100 kg/ha was used, and all other agronomic practices were carried out according to local recommendations.

Data collected

Disease severity was visually assessed using previously described (Arabi *et al.,* 1992; Daba *et al.* 2019; Tekauz, 1985) 1-9 reaction scale, to evaluate the infection of barley by *Pyrenophora teres* f. *maculata*. Disease score was recorded every 12 days. To quantify the disease severity, the collected data were converted to a Percent Disease Severity Index (PDSI) using the following formula:

$$\text{PSI}=\frac{\text{Sum of individual numerical rating}}{\text{total no. of plants assessed} \times \text{max. score in scale}} \times 100$$

Whereas, the sum of severity scores is the total score obtained from all plants, total number of plants observed is the number of plants assessed for disease, highest severity score is the maximum score on the 1-9 scale.

Finally, from each day severity assessments, area under disease progress curve (AUDPC) was calculated by using a previously described formula (Bocianowski *et al.,* 2020) as follows:

$$\text{AUDPC} = \sum_{i=1}^{n-1} (0.5(X_i + X_{i+1}))\,(t_{i+1} - t_i)$$

Where Xi= the severity index (PSI) of disease at the assessment, ti= the time of the assessment in days from the first assessment date, and n= the total number of disease assessments (Campbell & Madden, 1990). Since Severity was expressed in percentage and time in days, AUDPC was expressed in %-days.

Barley genotypes were classified based on their area under disease progress curve (AUDPC) values to determine their level of resistance to the disease. Genotypes with an AUDPC score of less than 250 were categorized as resistant (R), those with scores ranging from 250 to 499 were classified as moderately resistant (MR), scores between 500 and 749 indicated moderate susceptibility (MS), and those with AUDPC values exceeding 750 were deemed susceptible (S). This classification helps in evaluating and selecting barley lines based on their resistance to disease (Joshi *et al*., 2007).

Statistical analysis

Descriptive statistics was used for summarizing the data obtained from the field experiments. Microsoft Excel version 10 was used for calculation of AUDPC value and to plot histogram graphs across all lines, parental lines and years. Analysis of variance for alpha lattice design was carried out with the 'agricolae' package version1.3-3 (de Mendiburu, 2020), implemented in R environment (R Core Team, 2021). Analysis of variance was done for the area under disease progress curve.

Results and Discussion

The cropping seasons conditions were suitable for the life cycle of *P. teres maculate* as the temperature and moisture were as required by the pathogen to cause the disease (Table 2). The ascospores production is temperature-dependent with an optimum between 15 and 20°C (Mironenko *et al*., 2005). Infection of barley by ascospores requires free surface moisture or high (95-100%) relative humidity.

Area under disease progress curve (AUDPC) was markedly lower in the 2023 cropping season (606.2 %-days) compared to 2022 (1553.5 %-days) (Table 4), with a higher proportion of lines (75.8%, n=391) categorized as susceptible in 2022 (Figure 1). This increase in susceptibility in 2022 is likely attributed to higher rainfall and cooler temperatures during that season (Table 2). Previous research has documented variations in spot blotch severity and disease reactions of barley genotypes across different years and under various inoculation conditions (Singh *et al*., 2014). The rate of an epidemic progress is influenced by environmental factors including relative humidity, leaf wetness, and temperature (Mathre, 1997).

The frequency of genotypes with different reaction types for individual test year is shown in Figure 1. The evaluation of recombinant inbred lines (RILs) for resistance to spot forming net blotch, as per Bocianowski *et al.,* 2020 method, revealed substantial variability in disease response across years. In both years, there was a predominance of susceptible and moderately susceptible lines. In 2022, a large proportion of lines were classified as susceptible, while in 2023, the distribution was more balanced, with a significant proportion of lines showing moderate resistance.

Table 1. Parental lines type, characteristics, and origin of IMAGIC population.

Name	Type	Rows	Traits of Interest	Origin
HB1307	Improved	6	Yield, disease resistance, lodging resistance	Cross made at Holetta from Awura gebs1/IBON 93/91
Gobe	Improved	2	Earliness	
Agegnehu	Improved	6	Yield and marginal environment	Obtained from accession # 218950
64068	Farmer variety	6	Yield, lodging, earliness, disease	
Sasa	Farmer variety	2	Earliness	Tigray region
235056	Farmer variety	6	Yield, lodging, disease, marginal environment	
HB42	Improved	6	Disease resistance	Cross made at Holetta from IAR/H/81/Composite 29//Compound14/20/Coast
64065	Farmer variety	6	Yield, earliness, quality	
EH1493	Improved	6	Yield and disease resistance	Cross made at Holetta from white sasa/Composite 29//white sasa
HB1964	Improved	2	Quality (Malt barley)	
Miscal-21	Improved	2	Lodging and disease resistance	Selection from ICARDA germplasms and released as dual-purpose barley
219578	Farmer variety	6	Yield, marginal environment, lodging resistance, quality	
Ibon174/03	Improved	2	Dual purpose (food and malt), disease, earliness	
Sabini	Improved	2	Disease (susceptible), earliness, tillering	Introduced from Kenya
17244	Farmer	2	Quality (seed quality), naked barley, earliness	
Shegie	Improved	6	Marginal environment, disease resistance, biomass	Derived from landrace accession # 3336 obtained from EIB through pure line selection

Source: Ethiopian Agriculture Authority (2021).

Table 2. Total rainfall, minimum and maximum temperature at Dabat for 2022 and 2023 cropping seasons.

	Minimum temperature (°C)		Maximum temperature (°C)		Total rainfall (mm)	
Months	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
June	17.875	17.57433	28.81991	28.535	167.90	188.36
July	16.45226	17.02935	22.80087	26.74089	380.53	253.01
August	16.04097	16.67032	21.97566	24.95207	288.28	209.67
September	15.10633	16.71724	23.93276	26.97307	146.80	129.00

In 2022, about 75.8%, (n=391) lines were classified as susceptible, 17.1% (n=88) as moderately susceptible, 4.3% (n=22) as moderately resistant, and 0.39% (n= 2) as resistant. This suggests a broad range of susceptibility among the tested lines, with a predominance of susceptible and moderately susceptible responses. The susceptible check Sabine was susceptible and Resistance check Miscal-21 was resistant. In 2023, a repeat of the experiment yielded slightly different results. Out of the tested lines, around 22.1% (n=114) were susceptible, 43.6% (n=225) were moderately susceptible, 33.5% (n=173) were moderately resistant and 0.78% (n= 4) were resistant. Similarly, the susceptible check Sabine was susceptible and Resistance checks Miscal-21 and HB42 were resistant.

The analysis of variance showed highly significant differences ($p \leq 0.001$) in AUDPC values among the entries across both years (Table 3). The barley lines with practical value for SFNB resistance breeding are summarized in Table 2, indicating their reaction ratings as resistant (R), moderately resistant (MR), moderately susceptible (MS), or susceptible. One sample T-test in pedigree analysis showed significant variation in resistance among and within parental lines across both years (Tables 1 and 4). Notably, crosses from the parental line iMB/HB1307/219578/miscal-21/ibon174/03-1-f7 demonstrated the highest resistance, followed by those from iMB//Hb1307/Gobe/Agegnehu/64068. In contrast, crosses from the parental line iMB//Hb1307/SABINI/SHEGE/17244-1/f7 were less resistant compared to the others (Table 4).

Table 3. Analysis of variance of the area under disease progress curve (AUDPC) for barley lines in Dabat, Ethiopia.

Source of variation	df	MSS
Lines	495	278476**
Block	6	1191720**
Year	1	1.75E+08**
Error	487	174254

**= highly significant ($p \leq 0.001$); df= degrees of freedom; MSS=mean sum of square

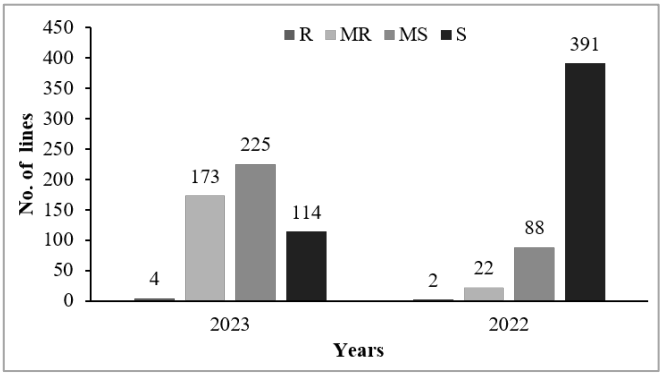


Figure 1. Frequency distribution of spot blotch reaction of barley lines evaluated at Dabt under natural epiphytotic conditions in 2022 and 2023. R= Resistant, MR= Moderately resistant, MS= Moderately susceptible, and S= Susceptible.

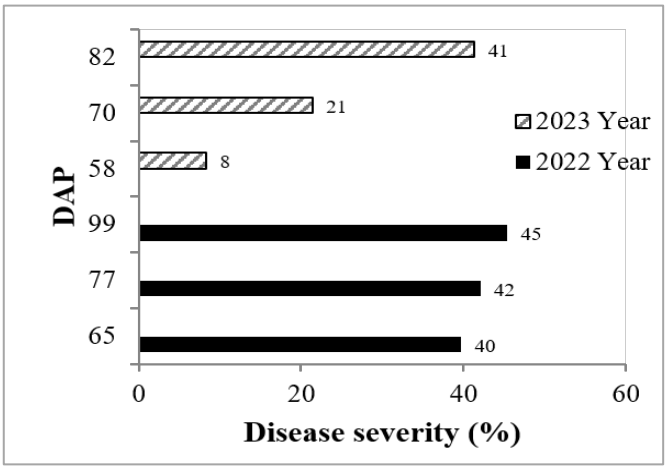


Figure 2. Spot type net blotch progress bar on barley at Dabat in 2022 and 2023 cropping seasons.

Tested lines showed moderately resistant, moderately susceptible and susceptible response in both seasons (Tables 5 and 6). Seventeen RILs that showed consistent moderate resistance across both years were the lines 18, 19, 48, 82, 176, 180, 216, 254, 345, 404, 429, 432, 440, 468, 478, 491, and 511 (Table 5). Their ability to maintain moderate resistance under varying conditions suggest that they are strong candidates for further evaluation and potential inclusion in breeding programs aimed at enhancing disease resistance. This consistency is valuable for developing crops with improved resistance to spot forming net blotch and for understanding the genetic basis of resistance in these lines.

A study by Asnakech *et al*. (2005), where ten barley differential lines and one susceptible check genotype were inoculated with 30 isolates of the two types of net and spot-forms of net blotch at seedling crop stages. Genotypes CI 4929, CI 5401, CI 2750, CI 7584, CI 739, CI 2235, and CI 4407-1 were resistant to all 30 *P. teres* isolates. Similar studies by McLean *et al*. (2011) identified fifteen lines (81-82/033, Arimont, BYDV-018, CBSS97M00855T-B2-M1-Y1-M2-Y-1M-0Y, CI9776, Keel, Sloop, Torrens, TR326, VB0111, VB0229, WI-2477, WI2553, Wisconsin Pedigree and Yarra that were resistant to all isolates at the adult stage.

It can be concluded that this study identified several barley lines that showed potential as a source of resistance to spot blotch (SB) for breeding programs. Despite the discovery of resistance in these lines, the overall levels of resistance and the number of resistant lines are relatively low, with no lines exhibiting complete immunity to the disease.

Specifically, the following recombinant inbred lines (RILs) were found to be resistant to spot blotch across two consecutive years: 18, 19, 48, 82, 176, 180, 216, 254, 345, 404, 429, 432, 440, 468, 478, 491, and 511.

These results indicated that while moderate resistance is present in these RILs, it was not absolute. The persistence of resistance in these specific lines suggests that these lines could be valuable for breeding programs focusing on improving resistance to spot blotch. However, ongoing evaluation and further research are necessary to better understand the genetic basis of this resistance and to effectively incorporate these lines into breeding strategies for managing spot blotch in barley.

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Table 4. Mean AUDPC, standard error, and T-Test of parental lines/cultivars of barley against spot forming net blotch at Dabat in 2022 and 2023 cropping seasons.

	Mean AUDPC		SE		T-Value		DF		
Parental lines/cultivars	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**p**
iMB//Hb1307/Gobe/Agegnehu/64068	1325.5	530.3	64.5	17.1	20.6	31.0	98	99	*
iMB//HB1307/sasa/HB42/235056	1569.4	609.5	64.1	20.0	24.5	30.4	99	99	*
iMB//Hb1307/64065/HB1964/Eh1493-1/f7-26	1536.5	653.7	61.5	22.3	25.0	29.3	96	98	*
iMB//Hb1307/SABINI/SHEGE/17244-1/f7	1706.3	708.2	62.9	24.9	27.1	28.4	93	96	*
iMB/HB1307/219578/miscal-21/ibon174/03-1-f7	1161.2	529.5	62.1	19.0	18.7	27.9	95	99	*
Mean	1553.5	606.2							

*= Significant (p≤0.05), SE= Standard Error, T= T test, DF= Degrees of Freedom

Table 5. IMAGIC Population exhibiting a moderately resistant response to spot form net blotch in Barley at Dabat, North Gondar, during the 2022 and 2023 cropping seasons.

	2022		2023	
RIL No.	**AUDPC**	**PR**	**AUDPC**	**PR**
18	499	MR	387	MR
19	485	MR	360	MR
48	363	MR	280	MR
82	484	MR	373	MR
176	485	MR	320	MR
180	498	MR	360	MR
216	490	MR	493	MR
254	665	MS	280	MR
345	439	MR	400	MR
404	363	MR	400	MR
429	498	MR	307	MR
432	288	MR	400	MR
440	478	MR	373	MR
468	516	MR	227	R
478	492	MR	253	MR
491	439	MR	387	MR
511	363	MR	400	MR

RILs= Recombinant Inbreed Lines, AUDPC=Area under Disease Progress Curve, PR= Population reaction, MR= Moderately Resistant, and IMAGIC=Interconnected Multi Parent Advanced Generation Inter Cross

Table 6. IMAGIC population exhibiting a moderately susceptible and susceptible response to spot form net blotch in barley at Dabat, North Gondar, during the 2022 and/or 2023 cropping seasons.

	Year					Year					Year			
RIL	**2022**		**2023**		**RIL**	**2022**		**2023**		**RIL**	**2022**		**2023**	
No.	**AUDPC**	**PR**	**AUDPC**	**PR**	**No.**	**AUDPC**	**PR**	**AUDPC**	**PR**	**No.**	**AUDPC**	**PR**	**AUDPC**	**PR**
A					31	2479	S	360	MR	61	665	MS	733	MS
1	665	MS	680	MS	32	2328	S	587	MS	62	2932	S	440	MR
2	665	MS	333	MR	33	2328	S	627	MS	63	2479	S	627	MS
3	665	MS	493	MR	34	2630	S	560	MS	64	968	S	453	MR
4	665	MS	467	MR	35	2177	S	600	MS	65	968	S	1107	S
5	1421	S	320	MR	36	1572	S	453	MR	66	1723	S	680	MS
6	665	MS	507	MS	37	1421	S	520	MS	67	1421	S	640	MS
7	2177	S	320	MR	38	1723	S	733	MS	68	665	MS	253	MR
8	1421	S	747	MS	39	2932	S	453	MR	69	1723	S	707	MS
9	665	MS	360	MR	40	665	MS	867	S	70	1421	S	547	MS
10	1874	S	720	MS	41	968	S	480	MR	71	665	MS	453	MR
11	1270	S	680	MS	42	1723	S	720	MS	72	665	MS	320	MR
12	968	S	387	MR	43	363	MR	747	MS	73	665	MS	587	MS
13	2177	S	653	MS	44	1421	S	720	MS	74	1723	S	520	MS
14	1421	S	573	MS	45	1874	S	707	MS	75	2177	S	973	S
15	665	MS	400	MR	46	2177	S	333	MR	76	1723	S	467	MR
16	665	MS	293	MR	47	1648	S	427	MR	77	817	S	600	MS
17	817	S	333	MR	49	1421	S	733	MS	78	1874	S	507	MS
20	1270	S	280	MR	50	1874	S	453	MR	79	665	MS	627	MS
21	665	MS	307	MR	51	968	S	440	MR	80	1194	S	533	MS
22	817	S	387	MR	52	665	MS	307	MR	81	1723	S	373	MR
23	817	S	613	MS	53	665	MS	547	MS	83	*	*	387	MR
24	665	MS	307	MR	54	1119	S	573	MS	84	1421	S	360	MR
25	1723	S	440	MR	55	665	MS	307	MR	85	1874	S	720	MS
26	1119	S	920	S	56	665	MS	640	MS	86	665	MS	467	MR
27	2328	S	507	MS	57	665	MS	533	MR	87	1421	S	293	MR
28	1119	S	533	MS	58	1723	MS	707	MS	88	968	S	413	MR
29	665	MS	453	MR	59	1421	MS	600	MS	89	2403	S	587	MS
30	1723	S	733	MS	60	1723	MR	493	MS	90	1421	S	627	MS

RIL No.	Year 2022 AUDPC	PR	2023 AUDPC	PR	RIL No.	Year 2022 AUDPC	PR	2023 AUDPC	PR	RIL No.	Year 2022 AUDPC	PR	2023 AUDPC	PR
91	1648	S	907	S	147	665	MS	320	MR	205	968	S	1347	S
92	1874	S	587	MS	148	2177	S	520	MS	206	1874	S	813	S
93	817	S	413	MR	149	665	MS	453	MR	207	968	S	613	MS
94	1119	S	293	MR	150	1421	S	253	MR	208	1723	S	560	MS
95	665	MS	507	MS	151	817	S	707	MS	209	2177	S	560	MS
96	2177	S	560	MS	152	1874	S	440	MR	210	1421	S	560	MS
97	2177	S	613	MS	153	2177	S	520	MS	211	2403	S	840	S
98	1874	S	747	MS	154	1723	S	347	MR	212	1723	S	627	MS
99	1421	S	400	MR	155	2177	S	707	MS	213	2328	S	493	MR
B					156	2177	S	707	MS	214	1723	S	680	MS
100	817	S	627	MS	157	2177	S	947	S	215	1421	S	707	MS
101	892	S	787	S	158	1270	S	693	MS	217	1572	S	827	S
102	1723	S	547	MS	159	1723	S	1280	S	218	1874	S	240	R
103	665	MS	547	MS	160	1572	S	613	MS	219	1572	S	1160	S
104	1723	S	453	MR	161	968	S	440	MR	220	665	MS	1053	S
105	665	MS	547	MS	162	665	MS	320	MR	221	1799	S	400	MR
106	1723	S	600	MS	163	2177	S	453	MR	222	1119	S	320	MR
107	1421	S	640	MS	164	968	S	600	MS	223	892	S	760	S
108	1421	S	733	MS	165	2177	S	307	MR	224	1421	S	813	S
109	2479	S	787	S	166	1421	S	440	MR	225	1723	S	600	MS
110	2025	S	760	S	167	665	MS	400	MR	226	2705	S	787	S
111	665	MS	640	S	168	2177	S	747	MS	227	1874	S	573	MS
112	1421	S	587	MS	169	2479	S	693	MS	228	892	S	680	MS
113	817	S	320	MR	170	2177	S	387	MR	229	1421	S	413	MR
114	1345	S	707	MR	171	892	S	853	S	230	2554	S	667	MS
115	1723	S	707	MS	172	665	MS	840	S	231	1874	S	773	S
116	2630	S	653	MS	173	1421	S	440	MR	232	1421	S	573	MS
117	1572	S	600	MS	174	1723	S	640	MS	233	1043	S	600	MS
118	1950	S	827	MS	175	665	MS	653	MS	234	968	S	667	MS
119	1421	S	627	MS	177	1723	S	960	S	235	1119	S	320	MR
120	1270	S	627	MR	178	1421	S	480	MR	236	1723	S	667	MS
121	665	MS	707	S	179	2025	S	947	S	237	817	S	547	MS
122	2403	S	440	S	181	1421	S	493	MR	238	817	S	547	MS
123	2177	S	533	MR	182	1421	S	773	S	239	1421	S	560	MS
124	1572	S	1040	MS	183	1421	S	307	MR	240	2177	S	1133	S
125	1799	S	640	MS	184	1874	S	587	MS	241	2403	S	1013	S
126	1723	S	627	S	185	2479	S	920	S	242	1723	S	747	MS
127	2252	S	680	MR	186	1723	S	627	MS	243	2932	S	880	S
128	1723	S	720	S	187	1119	S	640	MS	244	1421	S	707	MS
129	665	MS	453	MR	188	968	S	373	MR	245	1421	S	667	MS
130	665	MS	520	S	189	2177	S	613	MS	246	2177	S	853	S
131	1874	S	760	S	190	2328	S	813	S	247	665	MS	853	S
132	1421	S	280	MR	191	2479	S	453	MR	248	1421	S	293	MR
133	2328	S	560	MS	192	1119	S	787	S	249	1723	S	453	MR
134	1723	S	520	MS	193	1421	S	1027	S	250	1421	S	600	MS
135	2328	S	667	MS	194	363	MR	613	MS	251	2932	S	787	S
136	1874	S	533	MS	195	1723	S	587	MS	252	2479	S	1040	S
137	1421	S	973	S	196	1723	S	533	MS	253	1421	S	307	MR
138	2479	S	920	S	197	2630	S	920	S	255	1874	S	387	MR
139	1421	S	773	S	198	2932	S	520	MS	256	2177	S	667	MS
140	2328	S	413	MR	199	665	MS	573	MS	257	2328	S	653	MS
141	1421	S	707	MS	200	1270	S	480	MR	258	1421	S	493	MR
142	665	MS	320	MR	**C**					259	1723	S	707	MS
143	968	S	907	S	201	665	MS	440	MR	260	2101	S	733	MS
144	665	MS	307	MR	202	1421	S	400	MR	261	1874	S	640	MS
145	2630	S	253	MR	203	1723	S	733	MS	262	1421	S	573	MS
146	2932	S	573	MS	204	665	MS	587	MS	264	2025	S	747	MS

RIL No.	Year 2022 AUDPC	2022 PR	2023 AUDPC	2023 PR	RIL No.	Year 2022 AUDPC	2022 PR	2023 AUDPC	2023 PR	RIL No.	Year 2022 AUDPC	2022 PR	2023 AUDPC	2023 PR
265	1799	S	1133	S	321	2025	S	707	MS	381	665	MS	560	MS
266	*	*	373	MR	322	1723	S	840	S	382	2177	S	840	S
267	1874	S	800	S	323	1723	S	320	MR	383	1421	S	613	MS
268	665	MS	627	MS	324	1119	S	613	MS	384	2554	S	1040	S
269	665	MS	360	MR	325	1572	S	947	S	385	2328	S	733	MS
270	1723	S	893	S	326	*	*	333	MR	386	2932	S	1040	S
271	1723	S	680	MS	327	665	MS	667	MS	387	1421	S	1040	S
272	1799	S	973	S	328	1270	S	707	MS	388	1421	S	480	MR
273	1345	S	493	MR	329	1119	S	853	S	389	2630	S	760	S
274	493	MR	440	MR	330	1421	S	1053	S	390	1874	S	*	*
275	1874	S	973	S	331	2630	S	787	S	391	1421	S	640	MS
276	2252	S	680	MS	332	2403	S	653	MS	392	1421	S	707	MS
277	1572	S	800	S	333	2177	S	1360	S	393	2177	S	573	MS
278	2781	S	867	S	334	2177	S	760	S	394	2479	S	813	S
279	968	S	453	MR	335	1421	S	333	MR	395	1723	S	600	MS
280	892	S	320	MR	336	1421	S	1307	S	396	1874	S	907	S
281	817	S	453	MR	337	817	S	680	MS	397	1723	S	800	S
282	*	*	707	MS	338	1874	S	760	S	398	*	*	*	*
283	968	S	373	MR	339	968	S	600	MS	399	2630	S	293	MR
284	1345	S	787	S	340	1421	S	760	S	401	1421	S	600	MS
285	2403	S	1080	S	341	1874	S	760	S	402	665	MS	320	MR
286	1421	S	320	MR	342	590	MS	600	MS	403	665	MS	773	S
287	2403	S	*	*	343	2932	S	1133	S	405	665	MS	453	MR
288	*	*	1053	S	344	1874	S	813	S	406	*	*	440	MR
289	1421	S	707	MS	346	1421	S	720	MS	407	1421	S	573	MS
290	665	MS	520	MS	347	2252	S	920	S	408	2630	S	373	MR
291	1421	S	787	S	348	2479	S	880	S	409	1119	S	333	MR
292	1421	S	493	MR	349	1119	S	680	MS	410	1421	S	627	MS
293	2177	S	627	MS	350	1874	S	733	MS	411	665	MS	693	MS
294	1421	S	587	MS	351	1119	S	693	MS	412	1421	S	613	MS
295	2177	S	893	S	352	1874	S	1040	S	413	665	MS	653	MS
296	968	S	520	MS	353	1421	S	680	MS	414	665	MS	587	MS
297	665	MS	533	MS	263	665	MS	627	MS	415	*	*	813	S
298	665	MS	507	MS	354	2479	S	787	S	416	1421	S	360	MR
299	2025	S	613	MS	355	1043	S	307	MR	417	1723	S	440	MR
300	665	MS	453	MR	356	2554	S	1000	S	418	1723	S	547	MS
D					357	1874	S	653	MS	419	1723	S	307	MR
301	*	*	*	*	358	1874	S	707	MS	420	1119	S	733	MS
302	665	MS	413	MR	359	665	MS	360	MR	421	665	MS	307	MR
303	*	*	813	S	360	2177	S	653	MS	422	1043	S	547	MS
304	665	MS	467	MR	361	1421	S	400	MR	423	665	MS	693	MS
305	2177	S	747	MS	362	1421	S	347	MR	424	892	S	413	MR
306	1421	S	813	S	363	1421	S	1173	S	425	1119	S	640	MS
307	665	MS	320	MR	364	1421	S	707	MS	426	439	MR	867	S
308	1421	S	360	MR	368	*	*	413	MR	427	817	S	627	MS
309	1572	S	640	MS	369	*	*	547	MS	428	817	S	653	MS
310	1421	S	413	MR	370	1421	S	547	MS	430	665	MS	400	MR
311	1723	S	667	MS	371	1723	S	440	MR	431	665	MS	680	MS
312	1874	S	760	S	372	892	S	400	MR	433	817	S	413	MR
313	1497	S	840	S	373	1194	S	587	MS	434	1497	S	600	MS
314	1950	S	1093	S	374	1270	S	1120	S	435	665	MS	333	MR
315	817	S	627	MS	375	1648	S	867	S	436	1119	S	840	S
316	2403	S	400	MR	376	2932	S	1093	S	437	892	S	707	MS
317	1648	S	480	MR	377	2932	S	600	MS	438	1043	S	360	MR
318	2403	S	1040	S	378	2479	S	720	MS	439	590	MS	840	S
319	2328	S	1160	S	379	2177	S	1280	S	441	1874	S	613	MS
320	1421	S	520	MS	380	1723	S	480	MR	442	514	MR	680	MS

RIL No.	Year 2022 AUDPC	PR	2023 AUDPC	PR	RIL No.	Year 2022 AUDPC	PR	2023 AUDPC	PR	RIL No.	Year 2022 AUDPC	PR	2023 AUDPC	PR
443	2177	S	573	MS	469	665	MS	320	MR	496	1421	S	680	MS
444	1723	S	387	MR	470	212	R	294	MR	497	1874	S	587	MS
445	1874	S	813	S	471	1421	S	627	MS	498	665	MS	787	S
446	1421	S	467	MR	472	665	MS	427	MR	499	817	S	733	MS
447	1421	S	587	MS	473	212	R	293	MR	500	665	MS	467	MR
448	1421	S	640	MS	474	665	MS	240	R	501	*	*	367	MR
449	1572	S	747	MS	475	1874	S	267	MR	502	1874	S	707	MS
450	665	MS	547	MS	476	968	S	587	MS	503	2177	S	1000	S
451	1421	S	360	MR	477	2328	S	787	S	504	1119	S	987	S
452	1723	S	307	MR	479	968	S	627	MS	505	1572	S	653	MS
453	1723	S	627	MS	480	665	MS	760	S	506	665	MS	640	MS
454	1421	S	387	MR	481	665	MS	533	MS	507	2025	S	840	S
455	1421	S	800	S	482	2932	S	493	MR	508	665	MS	453	MR
456	665	MS	387	MR	483	2630	S	440	MR	509	2328	S	760	S
457	2328	S	440	MR	484	2479	S	467	MR	510	1421	S	733	MS
458	665	MS	320	MR	485	2177	S	813	S	512	1421	S	653	MS
459	1421	S	360	MR	486	817	S	227	R	513	968	S	1093	S
460	1421	S	267	MR	487	1421	S	627	MS	514	1421	S	560	MS
461	1874	S	307	MR	488	665	MS	360	MR	515	665	MS	680	MS
462	1648	S	467	MR	489	665	MS	453	MR	516	514	MR	600	MS
463	741	MS	280	MR	490	892	S	867	S	517	***		667	MS
464	1421	S	320	MR	492	1270	S	1027	S	518	***		627	MS
465	2177	S	587	MS	493	1043	S	693	MS	519	***		373	MR
466	*	*	627	MS	494	1723	S	760	S	520	***		307	MR
467	*	*	973	S	495	665	MS	333	MR					

RILs= Recombinant Inbreed Lines, AUDPC=Area under Disease Progress Curve, PR= Population reaction, R= Resistant, MR= Moderately Resistant, MS= Moderately Susceptible, S= Susceptible, and *= Not germinated and ***= Not sown in 2022 and A= Cross from iMB//Hb1307/Gobe/Agegnehu/64068, B= Cross from iMB//HB1307/sasa/HB42/235056, C= Cross from iMB//Hb1307/64065/HB1964/Eh1493-1/f7-26,D= Cross from iMB//Hb1307/SABINI/SHEGE/17244-1/f7 and E= Cross from iMB/HB1307/219578/miscal-21/ibon174/03-1-f7

الملخص

أزاناو، أسفاو، أسيفا سينتايهو، تسفاي ألمو، تيودروس تسفاي، زينو طاهر وسويم أسيفي. 2026. الاستجابة الفيتوباثومترية لعشائر الشعير الناتجة عن التهجين البيني متعدد الآباء للأجيال المتقدمة المترابطة (IMAGIC) تجاه مرض التبقّع الشبكي (*Pyrenophora teres* f. *maculata*) تحت ظروف وبائية طبيعية في شمال غوندار، إثيوبيا. مجلة وقاية النبات العربية، 44(3):310–319. https://doi.org/10.22268/AJPP-001413

يُعدّ مرض التبقّع الشبكي المتسبّب عن الفطر *Pyrenophora teres* f. *maculata*، من الأمراض الرئيسة التي تصيب الشعير، ويسبّب خسائر كبيرة في المحصول تحت الظروف الملائمة، ولا سيما في المناطق الباردة والرطبة. جرى تقييم مجموعة مكوّنة من 500 سلالة شعير ناتجة عن تهجينات متقدمة متعددة الآباء ومترابطة (IMAGIC) من حيث مقاومتها لهذا المرض، وذلك باستخدام تصميم القطاعات غير المكتملة (الشبكة ألفا)، وتحت ظروف وبائية طبيعية، إلى جانب ست عشرة سلالة أبوية، في حقل دابات البحثي التابع لمركز غوندار للبحوث الزراعية، غوندار، إثيوبيا، ولموسمين متتاليين (2022 و 2023). تم تقدير شدة المرض بصرياً باستخدام مقياس من 1 إلى 9. أظهر تحليل التباين وجود فروق معنوية بين السلالات المدروسة في المساحة تحت منحنى تطور المرض (AUDPC). وقد كان تطور الوباء المرضي أقل بشكل واضح في موسم 2023 (606.2%–يوم) مقارنةً بموسم 2022 (1553.5%–يوم). أظهرت سبع عشرة سلالة مرباة داخلياً (RILs) مقاومة متوسطة وثابتة خلال كلا الموسمين، وهي: 18، 19، 48، 82، 176، 180، 216، 254، 345، 404، 429، 432، 440، 468، 478، 491، و 511. وتشير قدرتها على الحفاظ على مستوى مقاومة متوسطة تحت ظروف بيئية متباينة إلى أنها مرشّحة قوية لمزيد من التقييم والإدراج المحتمل في برامج التربية الهادفة إلى تعزيز مقاومة الشعير للأمراض.

كلمات مفتاحية: الشعير، سلالات تهجين متقدم متعددة الآباء ومترابطة، التبقّع الشبكي، المساحة تحت منحنى تطور المرض، المقاومة.

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