Evaluation of Barley Germplasm for Resistance to Barley Leaf Rust (*Puccinia hordei* Otth)

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Abstract

Sixty-five barley entries (25 pure lines from landraces; 22 accessions from PGRC/E, and 18 local crosses) were studied for barley leaf rust resistance in a randomized complete block design with two replications. The entries were compared with a susceptible check, Trompillo. The trial was conducted for two seasons (1995 - 1996) at four locations (Ambo, Adet, Sinana and Sheno Research Centers). A significant variation among the entries was observed for the three characters studied (disease severity mentioned here as Average Coefficient of Infection (ACI), earliness and thousand kernel weight). Several entries showed different reactions to the disease at different locations i.e. low at one or more locations and high at others. This would mean that there were differences in the pathogen populations from location to location and the host entries used in this study. Of all the entries studied, EH 1051/F_2 -147H-31-15 was the most resistant to barley leaf rust across the four locations. But, on the basis of the over all location mean several entries may be considered resistant to the disease. The observed resistance was a quantitative type of resistance.
The relationships between disease severity with earliness and thousand kernel weight were negative and significant

Introduction

Barley is an important food and feed crop in many regions of the world. It is attacked by many diseases that limit yields and reduce the quality of the grain harvested (Bockelman et al. 1981). In Ethiopia, barley is infected with 23 fungal diseases. Scald (*Rhynchosporium secalis*), blotches (*Helminthosporium* spp.) and rusts (*Puccinia* spp.) are among the most widely distributed pathogens in the country (Eshetu 1985).

Barley leaf rust is generally distributed wherever barley is grown and is favored by a relatively warm and moist climate (Dickson 1956; Bockelman et al. 1981; Gareth & Clifford 1983). Survey studies in the past indicated that disease severity of 80 to 100% was recorded in barley growing areas of Arsi, Bale, Wellega, Gojam and parts of Shewa (SPL 1986). Epidemics of barley leaf rust have been recorded in Ambo, Adet, Sinana, Shashemene and Jima areas (Yitbarek et al. 1996; Getaneh & Temesgen 1996). A yield loss of up to 28% was recorded on farmers fields around Ambo (PPRC 1998) and up to 40% on lately planted susceptible variety Trompillo was recorded in the PPRC trial field (PPRC 1997; Getaneh 1998). This is high when compared with losses in other countries (Stubbs et al. 1986). A yield loss of 23% was also reported in Canada (Melville et al. 1976). In addition, barley leaf rust adversely affects grain number, malting quality, vigor and plant growth of barley crop (Stubbs et al. 1986; Mathre 1987; Sapkal et al. 1992).

Disease control may involve genetic resistance of the host or the use of systemic fungicides (Gareth & Clifford 1983; Mathre 1987; Gair et al. 1983). If available, genetic resistance is by far the most important. It is assumed that resistant varieties add little or nothing to the cost of production (Gareth & Clifford 1983; Mathre et al. 1987; Bockelman et al. 1981).

Study for disease resistance should be conducted at a number of locations. This is mainly due to differences in the pathogen population of barley leaf rust that may occur (Gareth & Clifford 1983). It is also known that in areas where severe epidemics occur a new race or virulence may appear as well (CIMMYT 1976). The observed resistance could be either polygenic or race specific. So far, more than 52 physiologic races of *Puccinia hordei* have been reported in the world (Fadeev 1977). Although no enough research was done, several physiologic races of *P. hordei* have been reported in Ethiopia (Yitbarek et al. 1996) which may indicate the possibility of variation in the pathogen. This offers the best means of controlling barley leaf rust and it is an important objective for barley improvement program (Bockelman et al. 1981; Gareth & Clifford 1983; Stubbs et al. 1986; Fekadu & Hailu 1987). The purpose of this study was therefore, to identify leaf rust resistant barley germplasm which may be useful in the national barley improvement program.

Materials and Methods

Sixty-five barley entries (25 pure lines from landraces; 22 PGRC/E accessions; 17 local crosses and 1 cross from CIMMYT) previously selected from preliminary disease screening nurseries for some level of resistance, Trompillo, leaf rust susceptible variety and local Ambo were included in the study. Eleven of the crosses were derived from exotic parents; five of the crosses were derived from both local and exotic parents and two crosses were from local parents. The nursery was conducted at Ambo (West Shewa), Adet (Gojam), Sinana (Bale) and Sheno (North Shewa) research centers for two seasons (1995 - 1996). A mixture of susceptible checks was planted between and around replications.

A randomized complete block design with two replications was used. Each entry was sown to one row plot of 1 meter length with a row spacing of 0.3 meter. Fertilizer was applied at the rate of 41/46, N/P Kg ha $^{-1}$. The trial was twice hand weeded. Data such as days to heading (DHE), thousand kernel weight (TKW) and percent severity and response of the entries to leaf rust were collected according to Stubbs et al. (1986). Weather data like rainfall and air temperature of the barley growing seasons are shown in Table 1. To ensure the level of resistance available in the host to leaf rust, Average Coefficient of Infection (ACI) was used as a selection criterion. The response of each entry has constant value, i.e., Resistant ® - 0.2; Moderately Resistant (MR) - 0.4; Intermediate (M) - 0.6; Moderately Susceptible (MS) - 0.8 and Susceptible (S) - 1.0. The constant value was multiplied with severity score of each entry per site and across sites to obtain a mean ACI value for the two years. Germplasm with a mean ACI value of up to 10 were considered as resistant to leaf rust (CIMMYT 1976; Stubbs et al. 1986). Leaf rust severity, days to heading and thousand kernel weight were analyzed using an MSTAT-C. Correlation coefficient r, was computed to observe the relationships between barley leaf rust severity with earliness and TKW.

Results and Discussion

There was significant variation among the entries tested for the three characters studied (disease severity mentioned here as Average Coefficient of Infection (ACI), earliness and thousand kernel weight). This finding is in agreement with the results reported by Fekadu & Parlevliet (1996).

In 1995 - 1996 cropping seasons, the rain was abundant at Ambo, Adet and Sheno and the monthly mean air temperatures ranged from 10.3EC to 18.2EC (Table 1.). The severity of the disease, however, varied from location to location depending on the differences in environmental conditions; appearance of the disease at various growth stages of the crop and other related factors. Gair et al (1983) and Mathre (1987) have also indicated that barley leaf rust develops from as low as 3EC to as high as 30EC. But, most rapid development occurs at 15 - 25EC. Conducive weather condition (16.7 - 18.2EC) for the development of barley leaf rust was recorded at Ambo and Adet. The severity of the disease was the highest at Ambo. Even though the temperatures were suitable for the development of the disease at Adet, the severity was not high because of late appearance of the disease. At Sheno, the temperature ranges were not within the optimum requirement of the disease, thus the severity was less than that of Ambo.

The highest mean ACI value (41.1) of the barley leaf rust was observed at Ambo, while the lowest ACI value (21.5) was recorded at Adet. However, none of the tested entries was immune to the disease at all locations. The ACI value at Ambo varied from 0.2 to 95 where 0.2 was obtained on line EH 1051/F_2 -147H-31-15. The highest ACI value (95.0) was on line 3366-07. Twelve entries at Ambo had low ACI (# 10) values as compared to the susceptible check, Trompillo and Ambo local with ACI values of 90.0 and 85.0, respectively (Table 2)

At Adet, ACI values varied from 4.0 to 35.5 with a location mean of 21.5. The lowest ACI value (4.0) was recorded again on EH 1051/F_2 - 147H-31-15. The highest ACI value (35.5) was observed on line 3366-07. The former is a selection derived from a back cross of HB 37 with 4.73, while the latter was a selection derived from landrace population collected from Kofele district, Arsi region. At Adet only 8 entries had low ACI values. At Sinana, the ACI values varied from 0.6 to 47.0 with a mean of 23.0. The lowest ACI value (0.6) was recorded on line 3426-01, while the highest ACI value (47.0) was again scored on 3366-07. Line 3426-01 was a selection from landrace populations collected from Ambo district, West Shewa region. At this location, only 3 entries had low ACI values. At Sheno, ACI values varied from 3.0 to 77.0 with a location mean of 28.3. The lowest ACI value (3.0) was recorded on EH 1051/ F_2-147H-31-15 while the highest ACI value (77.0) was recorded on the susceptible check cultivar Trompillo. Five entries had low ACI values at Sheno.

Genotypes with low ACI values to barley leaf rust are considered resistant. In this study, several genotypes exhibited low ACI values at one or more locations. For instance, genotype X/F_2 (SW) -179-86-7-4-3 had low ACI value at Adet only. Lines 3304-06 and 3302-08 had low ACI values at Ambo and Adet. Others such as Acc. 202654 and line EH 1039/F_2- 61H-13-8 had low ACI values at Ambo and Sheno. Also, some others had low ACI values at more than two locations. This suggests that a genotype resistant at one or more locations, but susceptible in the other locations would mean that there was differences in virulence in the pathogen populations at a number of locations. This result may agree with the findings reported by Yitbarek et al. (1996). Moreover, since the testing sites are reported to be conducive for the development of leaf rust epidemics (Getaneh & Temesgen 1996; Yitbarek et al. 1996) new races might have occurred as described in CIMMYT wheat improvement report (1976). Among barley genotypes studied, EH 1051/F_2-147H-31-15 can be considered resistant, though not immune, from its low ACI values obtained at all four locations it was tested although it was still not immune. Some genotypes such as EH 1041/F_2-90H-21-13 showed good level of resistance at Ambo, Adet and Sheno and EH 922/F_2 -240H-53-39-1 was also resistant at Ambo, Adet and Sinana. The resistance they showed is quantitative type of resistance. These materials may have a good breeding value in the national barley improvement program. When considering the over all location mean, additional entries (EH 1039/F_2-61H-13-8, Acc.202654, and 3302-08) tended to be resistant (Tables 2 & 4).

All the genotypes were also grouped as accessions, pure lines and crosses (Table 3). The entries with each group are classified according to their ACI values. Most of the accessions and pure lines are skewed towards susceptibility, whereas most of the crosses skewed towards resistance.The relationship between barley leaf rust infections and earliness are negatively and significantly correlated ($r = -080$, $P < 0.01$). This means that resistance to leaf rust is associated with lateness whereby late maturing genotypes are more resistant than that of the early genotypes. This evidence is also substantiated from the data in Table 4. In this table, genotypes with low ACI values are relatively late maturing than the genotypes with high ACI values. A field trial carried out by Parlevliet and Moseman (1986) to identify barley lines resistant to barley leaf rust also showed that late maturing lines tended to be more resistant to the disease than the early ones. In addition, a significant negative correlation ($r = -0.215$, $P < 0.01$) was also observed between disease severity and thousand kernel weight. That means that genotypes with low ACI value had high TKW. The data in Table 4 also demonstrate a similar trend. There is also a good association between disease severity, earliness and TKW. Michael et al. (1989) reported a positive relationship between earliness and grain yield in barley. Shelembi and Wright (1991) have found the existence of positive correlation between TKW and grain yield; late maturing entries having higher TKW and higher grain yield. Our data is in line with these findings.

Table 1. Monthly rainfall and air temperature for barley growing periods at three locations, 1995 - 1996

Month	Rainfall (mm)			Temperature (EC)		
	Ambo	Adet	Sheno	Ambo	Adet	Sheno
June	156.7	179.7	74.9	18.2	18.2	13.0
July	254.5	361.9	316.8	16.9	17.0	12.5
August	185.8	355.9	286.5	16.6	16.7	12.8
September	114.6	209.2	58.8	17.4	17.2	12.3
October	6.1	24.4	0.1	17.7	16.5	12.4
November	15.5	61.6	5.5	17.9	15.7	10.3

** = weather data is not available for Sinana*

Table 2. Average coefficient of infection (ACI) of sixty five barley entries and two checks at four locations 1995 - 1996 cropping seasons

No	Variety Designation	Pedigree/Collection site	ACI by location*				
			1	2	3	4	Mean
1	3305-18	Kofele/Arsi	30.0	23.0	26.0	18.5	24.4
2	3289-17	Moret/Jiru/ Shewa	80.0	33.0	30.2	57.5	50.2
3	3304-06	Kofele/Arsi	8.0	8.0	11.6	13.5	10.3
4	Acc. 202573	Robi/Arsi	19.0	13.0	12.5	37.5	20.5
5	Acc. 202598	PGRC/E	80.0	26.0	26.0	42.5	43.6
6	EH 902/F_2 -34H-4-3-3	33/79//Ardu 12 60B//Holkr/ Q .L.1.L	22.0	20.0	22.1	25.5	22.4
7	Acc. 202553	Gasera/Bale	60.5	25.0	24.2	17.0	31.7
8	3304-16	Kofele/Arsi	46.0	18.0	12.3	52.5	32.2
9	Acc. 202626	Sude/Arsi	36.0	27.5	21.0	31.0	28.9
10	Acc. 202593	PGRC/E	23.0	23.0	20.5	24.5	22.7
11	Acc. 202603	Banja/Gojam	64.0	24.0	22.3	16.5	31.7
12	X/F_2(SW)-179-86-7-4-3	CIMMYT	14.5	9.5	16.5	14.0	13.6
13	EH 1041/F_2- 88H-20-12	Ahor 880/61/6.73//HB 37	2.7	13.0	15.7	19.0	12.6
14	EH1090/F_2-12H-149-2	Beka/EH 163// HB 52/3/Holkr	44.0	18.0	23.0	36.0	30.2
15	Acc. 213728-29	PGRC/E	38.5	8.5	13.2	35.5	23.9
16	3304-04	Kofele/Arsi	24.5	9.0	14.8	20.5	17.2
17	EH 1041/F_2 - 90H-21-13	Ahor 880/61/6.73//HB 37	2.5	10.0	16.1	10.0	9.6
18	EH 956/F_2- 8H-6-4	260/79/HB 37/35/79/Ardu 12 60B	57.0	24.0	16.6	30.0	31.9
19	EH 905/F_2 - 94H-23-12	Netch Gebs/Aruso// Dura./Netch Gebs	13.5	19.0	15.6	30.0	19.5
20	EH 1037/F_2 - 50H-10-5	IAR/H/485/4.73//HB 37	30.0	19.5	23.5	23.0	24.0
21	Acc. 202591	PGRC/E	75.0	33.0	20.0	38.0	41.5
22	Acc. 202559	Gololcha/Bale	85.0	34.2	36.2	32.0	46.8
23	3336-12	Arba Gugu/Arsi	39.0	33.5	33.2	15.2	30.2
24	EH 1051/F_2- 147H-31-15	HB 37/4.73//HB 37	0.2	4.0	8.4	3.0	3.9
25	EH 1039/F_2- 61H-13-8	Ahor 880/61/4.73/HB 37	2.0	11.0	12.6	8.7	8.6
26	Acc. 213840-37	PGRC/E	2.2	10.2	13.9	19.5	11.4
27	Acc. 202574	Robi/Arsi	58.0	28.5	31.7	34.5	38.2
28	Acc. 202533	Gonder Zuria/Gonder	64.0	26.0	21.0	16.0	31.7
29	Acc. 202596	PGRC/E	66.0	26.0	25.2	20.0	34.3
30	EH 1042/F_2 - 95H-23-14	HB 42 /4.73//HB 37	15.0	17.0	15.3	23.0	17.6
31	1667-15	Mama Midir/ Shewa	50.0	22.0	11.5	30.0	28.4
32	3305-17	Kofele/Arsi	47.0	27.0	29.0	31.5	33.6
33	3366-01	Ticho/Arsi	49.5	25.0	38.0	34.0	36.6
34	Acc. 202654	Chencha/Gemu Gofa	3.4	13.7	12.2	5.5	8.7
35	EH 1051/F_2- 151H-32-16	HB 37/4.73//HB 37	18.0	18.0	14.2	9.2	14.8

No.	Variety Designation	Pedigree/Collection site	ACI by location*				
			1	2	3	4	Mean
36	1633-19	Angolela/ Shewa	55.0	28.0	27.0	42.0	38.0
37	3366-03	Kofele/Arsi	55.0	25.0	23.0	11.7	28.7
38	BSCN 61/89	ICARDA	41.5	17.0	21.0	55.0	33.6
39	3366-07	Kofele/Arsi	95.0	35.5	47.0	66.0	60.9
40	EH 922/F_2 - 247H-55-4-16	Commander/Unknown//Holkr/Unknown	6.2	21.0	13.2	17.0	14.3
41	3289-10	Adaba/Bale	57.5	26.0	23.0	11.0	29.4
42	3426-01	Ambo/Shewa	40.5	27.0	0.6	32.0	25.0
43	Acc. 202632	Damot Gale/ Sidamo	65.0	30.0	31.0	31.0	39.2
44	3289-10	Adaba/Bale	47.0	27.7	45.5	23.0	35.8
45	3366-05	Ticho/Arsi	80.0	35.0	51.2	55.0	55.3
46	3304-10	Kofele/Arsi	4.5	12.0	32.6	18.0	16.8
47	Acc. 202636	Koyesha/Sidamo	33.0	22.0	27.0	12.5	23.6
48	Acc. 202551	Gasera/Bale	35.0	20.0	27.5	10.2	23.2
49	3302-08	Kofele/ Arsi	7.0	8.0	10.1	13.0	9.5
50	1639(bulk)	PGRC/E	45.5	29.0	25.0	45.5	36.2
51	Acc. 202534	Gonder Zuria/Gonder	80.0	27.0	27.0	35.0	42.2
52	1791-13	Kofele/ Arsi	36.5	20.0	21.5	43.5	30.4
53	Acc. 202552	Gasera/Bale	46.0	25.0	23.0	26.0	30.0
54	Acc. 202583	Digela & Tijo/Arsi	54.0	21.0	21.2	41.0	34.3
55	1721-14	Kofele/Arsi	43.0	22.0	35.2	47.0	36.8
56	Composite bulk 10/90	Local/ Compound 1420	31.0	26.0	34.0	42.5	33.4
57	Acc. 202621	Dangla/Gojam	85.0	25.0	28.7	22.0	40.2
58	Acc. 202610	Denbecha/Gojam	82.5	23.2	27.5	41.5	43.7
59	3336-04	Arba Gugu/Arsi	72.5	31.0	27.0	15.5	36.5
60	3414-03	Sululta/ Shewa	32.5	16.0	30.2	15.0	23.4
61	EH 1041/F_2 - 80H-18-10	Ahor 880/61/6.73//HB 37	15.5	19.0	15.1	35.0	21.1
62	EH 905 /F_2 - 114H-27-4	260/79/HB 37/35/79/Ardu -12-60B	3.7	13.0	16.1	18.5	12.8
63	EH 954/F_2 - 4H-4-3	Duragna/Nech Gebs//HB-42	15.5	10.5	28.0	45.0	24.7
64	1633-14	Angolela/Shewa	41.0	32.0	20.2	37.5	32.7
65	EH 922/F_2 - 240H-53-39-1	Commander/Unknown//Holkr/UnknownWN	4.0	6.5	9.1	11.2	7.7
66	Trompillo(Susceptible Ck.)	-	90.0	32.0	35.5	77.0	58.6
67	Ambo local (Check)	-	85.0	26.0	29.3	29.0	42.3
	Mean		41.1	21.53	23.0	28.3	28.5
	LSD_{01}		33.2	10.4	18.6	24.0	11.5
	CV (%)		30.9	18.4	30.2	31.9	44.1

*[1] Ambo, [2] Adet, [3] Sinana, & [4] Sheno

Table 3. Distribution of sixty five barley germplasm over six ACI classes with a class interval of ten unites based on the four locations mean

Germplasm	N*	ACI classes					
		1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	> 50
Accessions	22	1	2	6	7	6	-
Pure lines	26	2	2	8	11	1	2
Crosses	17	4	7	5	1	-	-
Total	65	7	11	19	19	7	2

N = Number of entries tested*

Table 4. Sixty-five entries of barley as classified according to the ACI mean values over four locations as related to earliness and thousand kernel weight.

ACI values	N*	Mean ACI values	Mean earliness (days)	Mean TKW (g)
1 - 10	7	8.3	88	39.9
11 - 20	11	15.7	87	39.1
21 - 30	19	26.1	79	34.8
31 - 50	26	37.2	79	33.6
> 50	2	58.1	80	33.4

N = Number of entries tested*

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