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Research Article

Adaptability Study and Diseases Evaluation for Malt Barley (*Hordeum distichon L*) Varieties in North Shewa, Central Highlands of Ethiopia

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ABSTRACT

Central highlands of Ethiopia have immense potential for barley production and processing having not only suitable growing climatic and edaphic factors but also accessible markets as brewery factories are highly confined in the area. However, farmers have adopted production of local and food varieties with poor productivity. An experiment was conducted to select well performed, adaptable, high yielding and disease resistant varieties. Significantly lower AUDPC values of 78.63%, 90.77%, 108.97% and 355.37% were obtained from Ibon-174/03, EH-1847, Miscal-21 and Traveller varieties, respectively, while significantly higher AUDPC values of 2150.05%, 2074.33%, 1472.22% were recorded from Grace, Moeta and Bahati verities, respectively at Dege. Whereas, no visible symptoms were observed from Ibon-174/03, EH-1847 and Miscal-21 varieties at Wachale. The combined analysis of variance showed that the average grain yields of varieties Ibon-174/03 (4236.5 kg/ha), EH-1847 (4343.4 kg/ha) and Traveller (4415.25 kg/ha) were higher followed by varieties Bahati (3429 kg/ha) and Beka (3428.5 kg/ha). Disease severity had a strong and negative significant correlation with thousand kernel weight (-0.94), spike length (-0.77) and grain yield (-0.69). The variety Traveller gave the highest grain yield advantage over the overall grand mean and the low yielder varieties recorded were from Moeta and Grace. Generally, Ibon-174/03, EH-1847 and Traveller were the varieties that showed better performance with their mean yield and other measured traits. Therefore, these varieties were recommended to be adopted by the farmers of the study area so as to improve their livelihood through barely production.

Keywords: Adaptation; Resistance; Grain yield; Malt barley; Varieties

INTRODUCTION

Agriculture is the backbone of Ethiopian economy as it supports various crop and animal productions. Among the crop categories, barley (*Hordeum vulgare L.*) is the best staple food and subsistence crop in the country. It is cultivated in different agro-ecologies with the altitude range of 1,500-3,500 meters above sea level (m.a.s.l), but mostly grown between 2,000-3,000 m.a.s.l.

Barley is the fourth most cultivated crop of the world. In Ethiopia, it is ranked fifth following teff (*Eragrostis tef*), wheat (*Triticuma estivum L.*), maize (*Zea mays*) and sorghum (*Sorghum bicolor*) [1].

Malt barley (*Hordeum distichon L*) is becoming the main income source to small holder farmers in the highland areas of Ethiopia; particularly, where the agro-ecologies are not more productive to other cereal crops. However, in Ethiopia, barley productivity (2.66 t/ha) is lower as compared to that of other barley producing countries such as United Arab Emirates, Belgium and Netherlands (8 t/ha, 7.59 t/ha and 7.0 t/ha, respectively). This is due to the combination of genetic, socioeconomic constraints and inappropriate use of integrated technologies.

Ethiopia has large suitable cultivated land for barley production, which covers about 970,053 ha per year. It produces 347,497 tons barley per year. Similarly, Ethiopia has a high demand for malt barley products due to the previously established and new emerging brewery factories. The country has a total of four malt (two on process) and twelve brewery factories. In consideration of suitable agro-ecology and high demand for malt barley products by malt and brewery factories, Ethiopia has established a malt barley market value chain from the farmers to malt and brewery factories.

As reported by Berhanu, farmers in the highland areas of Ethiopia have simply produced barley for food security and local markets at lower prices due to lack of market value chains. Now, due to the emergence of malt and brewery factories, contract farming is evolved in malt barley commercialization among farmers,

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cooperatives, unions, seed enterprises, malt and brewery factories which have a 10% price advantage over non contracted farming. Even if the malt barley production and productivity are increased year after year, the supply does not meet the demand of emergence of malt and brewery factories. The brewery factories demanded about 118,000 tons of malt per year, while the local malt source is 52,000 tons which covers only about 50% of it [2].

This shortage can be compensated by increasing the production by testing and selecting better performing varieties at different agro-ecology of the country and in the study area in particular.

Mainly, farmers in the study area have been using food barley as a main food staffs. The significance of malt barley as a cash crop by supplying to different factories like beer industry is not well known in this area. For increasing the awareness of farmers towards the usage of malt barley technologies, it is important to provide improved malt barley varieties that increase production and productivity and enhance food security.

According to Mohammed and Getachew, major constraints for malt barley grain production were the current malt barley varieties generally not well adapted to higher altitude, confined to different agro-climatic zones, limited package of comprehensive cultural practices and poor quality grain such as high screen loss, low thousand kernel weight and disease susceptible varieties.

Many researches showed that host resistance is by far the most important defense mechanism that can be used to control diseases of agricultural crops. The deployment of varieties with disease resistance is one of the most effective and economic means of controlling plant diseases. Despite substantial advances made in developing disease management strategies, global food security is threatened by multitude of pathogens like scald which is caused by a haploid, imperfect fungus *Rhynchosporium secalis* and pests causing about 30% production losses annually. Especially in the highlands with high precipitation and low temperature during the cropping period, which is a scald favorable environment, yield loss reaching 67% has been reported in Ethiopia. Therefore, it is better to identify best performing varieties that combine adaptable, high yielding and disease resistant varieties for providing information to the growers and future breeding programs.

MATERIALS AND METHODS

Description of the study area

The study was carried out in North Shewa zone of Oromia Regional State, which is situated between 9°09'N to 10°39'N latitude and 38°85'E to 39°52'E longitude. It is bounded to the North and to the East by Amhara Regional State; to the West by west Shoa Zone of Oromia Regional State; to the South by Addis Ababa and to the south east by East Shoa Zone of Oromia Regional State. The altitude of the study area is generally in the range of 1000 to 3453 m.a.s.l. The average maximum monthly rainfall is 384 mm while the mean annual temperature in the Zone ranges from 9°C to 23°C [3,4].

Treatments and experimental design

The experiment was conducted in the main cropping season of 2020/2021 (June to January). Ten improved malt barley varieties were taken from Kulumsa, Holeta and Sinana agricultural research centers. The experiment was conducted at two locations of highland agro-ecologies of north Shewa Zone, namely; Degem and Wachale Districts.

Randomized Complete Block Design with three replications was used on plot size of 2 m × 1.2 m. Spacing of 20 cm, 0.5 m and 1 m between rows, plots and blocks, respectively, was used. The seeds were drilled in row for each variety at the seed rate of 100 kg/ha for rainfed conditions. The plots were fertilized with 46 kg/ha of P_2O_5 and 41 kg/ha of N. Half of the N rate was applied at planting together with full rate of P_2O_5 and the remaining half rate of N was applied at 35 days after planting.

Data collected

Days to heading and days to maturity were recorded when 50% of the plants give raise to heads and 90% of the plants fully attained physiological maturity, respectively. The weight of thousand kernels was sampled at random from the total grains, which was measured from each experimental plot. Plant height was measured from the ground to the spike excluding the awn from randomly selected ten plants and spike length (cm) was measured from base to top excluding the awn and expressed as an average of ten plants in a plot.

Grain yield per plot was measured in gram as weight of harvested grain from the middle four rows in each plot and the grain moisture was adjusted to 12.5% [5].

Disease severity

Leaf scald severity was assessed seven times from the middle of four rows from 10 randomly-selected and tagged plants at seven days interval starting from the onset of symptoms until the crop is matured. A severity assessment was done on a severity scale of 00–99, where the first digit indicates disease progress in canopy height from the ground level and the second digit refers to severity of the disease based on diseased leaf area. The disease severity scores were also converted to Percentage Severity Index (PSI).

$$\text{Percentage Severity Index (PSI)} = \frac{\text{Sum of individual ratings}}{\text{Number of plants assessed x maximum scale}} \times 100$$

Area under disease progress curve

Area under the disease progress curve was calculated for each plot using the equations developed by Sharma.

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

Where, n: number of observations;

ti: days after planting for the ith disease assessment;

xi: disease severity (incidence) in percent.

Statistical analysis

Data on PSI, AUDPC, Yield and Yield Related Trait were subjected to Analysis of Variance (ANOVA) according to Gomez and Gomez using SAS computer software package version 9.0. Means were separated using LSD at alpha=0.05 level of probability. Correlation analyses were conducted using Pearson Correlation analysis of Proc-Corr procedures of SAS computer software package version 9.0 [6].

RESULTS AND DISCUSSION

Phonological, growth, yield and yield related traits

Analysis of variance revealed the presence of highly significant difference among the tested varieties for days to heading, days to maturity; spike length, PSI, AUDPC, PH, TKW, GY and significant difference between varieties were recorded for DM [7-10].

Early heading was exhibited by variety Ibon174/03 (80.5 days), EH-1847 (84 days), Moeta (84.5 days) and Miscal-21(85 days) followed by Traveller (88.5 days). However, variety Grace (95.5 days) exerted late heading followed by Bekoji (93.5 days), Holker (92 days), Beka (91.5 days), Bahati (91 days) (Table 1). The difference in days to heading among the tested varieties ranged from 80.5 days to 95.5 days in combined mean effects of varieties. While selecting varieties for early maturing, considering early heading varieties could be very critical. The current result is also in agreement with the findings of Aliyi (2016); Alemu (2017) and Samuel (2022) who reported that the reason for delaying in days to 50% heading on malt barley varieties were the genetic difference of crops and adaptation to different agro-ecological zones.

Analysis of variance for days of maturity showed significant difference for all varieties at both tested locations. The longest days of maturity in combined mean effect of varieties were recorded by Bekoji-1 variety which was (132 days) followed by Traveller (129 days) and the shortest by Beka (111 days) to attain its full physiological maturity (Table 2). The early maturing varieties complete their life cycle relatively in short period of time, which has an advantage over the late maturing varieties when rainfall ceases early. Different researchers concluded that this is because of the genetic characteristics of the varieties [11-15].

Both the individual and combined analysis of the yield data showed a highly significant difference at $P<0.01$. From the individual location analysis, the higher yield was recorded from variety Traveller (4797.2 kg/ha) and Ibon-174/03 (4320 kg/ha) at Wachale District and from EH-1847 (4378.5 kg/ha) at Degem District. The combined analysis of variance also showed that the average grain yield of variety Ibon-174/03(4236.5 kg/ha), EH-1847(4343.4 kg/ha) and Traveller (4415.25 kg/ha) were higher followed by varieties Bahati (3429 kg/ha) and Beka (3428.5 kg/ha). The variety Traveller (4415.25 kg/ha) gave the highest grain yield advantage over the overall grand mean and the low yielder varieties were from Moeta and Grace.

In both cases significant variability was observed among the tested varieties across the locations for grain yield, which was ranged from 4797.2 kg/ha-1804.9 kg/ha. Grain yield is an important character, to be considered for variety selection, to address the objective of the conducted activity. These large differences could be associated with the relatively high heritability of varieties [16-20].

Moreover, the grain yield and yield relating characters in barley showed variation in different degrees due to their genetic materials i.e. the presence or absence of diseases resistance gene and adaptability potential of the agro-ecology of the area. Based on this actuality, three varieties i.e.Ibon-174/03, EH-1847 and Traveller were the best performing varieties in the studied areas [21,22].

The mean statistical analysis data indicated that the longest plant height (118.67 cm) was recorded from Bekoji-1 followed by Holker (106.67 cm), EH-1847 (102 cm) and Miscal-21 (97 cm) varieties. The shorter (72 cm and 74 cm) plant height was recorded from Traveller and Beka varieties, respectively, which were statistically non-significant with each other at Degem but statsticaly different at Wachale. The highest (118.67 cm) plant height was also recorded from Degem study site, whereas the lowest (71 cm) plant height was recorded from Wachale study site (Table 3).

Tallness character might not be a good character as it competes with grain yield for the food from the source during source-sink relationships; moreover, tallness exposes the plant to lodging. Aliyi noted that considering this character for variety evaluation is very crucial as it helps in selecting varieties able to withstand lodging problems.

Amare reported that the difference in varieties might be related to difference in the plant height of malt barley with respect to the environment.

Varieties showed a significant difference in spike length at each location as well as combined mean effect of varieties. A combined analysis of variance showed the highest spike length (8.23 cm) in variety Ibon-174/03 followed by EH-1847 (8.21 cm) and the lowest (6.01 cm) in Moeta followed by Holker 6.38 cm (Table 4) . This finding is in line with that of Aliyi who reported that variety Holker recorded minimum spike length [23-25].

Table 1: Effect of varieties on phonological, yield and yield components of malt barley varieties during the cropping season of 2020.

	Degem						Wachale					
Variety	PH	DH	DM	SL	TKW	GY	PH	DH	DM	SL	TKW	GY
Bahati	89	93	123.33	6.83	41.8	3866.7	87.6	89	117.3	6.69	40.48	2991.3
Beka	74	92	112.6	7.35	47.3	3369.5	79	91	109.6	7.72	44.63	3487.5
Bekoji-1	118.67	95	135	6.43	49.2	3205.5	116	92	129	6.36	46.61	2613.9
EH-1847	97.33	86	123b	8.1	50.5	4378.5	102	82	120.3	8.32	48.84	4308.3
Grace	68.67	97	124.33	6.79	39.1	2483.6	75.6	94	117.3	6.69	37.84	2113.9
Holker	105	93	123.6	6.33	45.5	3341.5	106.6	91	119.6	6.43	43.5	2890.3
Ibon-174/03	85.33	82	133	8.26	48.6	4152.1	85.6	79	122.6	8.2	48.31	4320.9
Miscal	96	87	127.6	7.29	52.7	2675	97	83	122.6	7.43	50.44	2963.9
Moeta	83	85	120.33	6.03	41.4	1804.9	82.3	84	114.2	5.99	37.82	2022.2
Traveller	72	101	129.6	7.85	51.9	4033.3	71	98	128.3	7.75	47.93	4797.2
Mean	88.9	91.1	125.26	7.12	46.84	3331.05	90.3	88.3	120.13	7.12	44.64	3250.93
CV (%)	5.51	0.6	5.09	2.21	3.2	15.47	3.88	0.63	3.56	3.33	2.83	13.21

Note: PH: Plant Height; DH: Days to Heading; DM: Days to Maturity; SL= Spike Length; TKW: Thousand Kernel Weight; GY: Grain Yield.

Table 2: Combined mean of diseases parameters, yield and yield-related trait performance in malt barley varieties across locations.

Variety	PH	PSI	AUDPC	DH	SL	DM	TKW	GY
Bahati	88.3	47.42	1331.75	91	6.76	120.33	41.15	3429
Beka	76.5	22.22	627.49	91.5	7.34	111.17	45.97	3428.5
Bekoji-1	117.3	18.91	539.64	93.5	6.39	132	47.94	2909.7
EH-1847	99.6	1.72	45.38	84	8.21	121.67	49.67	4343.4
Grace	72.2	73.45	2046.33	95.5	6.74	120.83	38.5	2298.8
Holker	105.8	44.37	1238.59	92	6.38	121.57	44.5	3115.9
Ibon-174/03	85	1.62	39.32	80.5	8.23	127.83	48.48	4236.5
Miscal-21	96.5	2.17	54.48	85	7.36	125.16	51.61	2819.4
Moeta	82.6	73.85	2074.33	84.5	6.01	117.17	39.66	1913.5
Traveller	71.5	9.21	248.27	88.5	7.8	129	49.93	4415.3
Mean	89.6	29.49	824.55	89.70	7.12	122.7	45.74	3290.99
CV (%)	4.09	3.63	4.00	0.34	2.64	4.00	2.46	12.36

Note: PH: Plant Height; PSI: Percentage Severity Index; AUDPC: Area Under Disease Progress Curve; DH: Days to Heading; DM: Days to Maturity; SL: Spike Length; TKW: Thousand Kernel Weight; GY: Grain Yield.

Table 3: Description of percentage severity levels and their host response.

SNo.	Variety	Disease Reaction	Host Response
1	Bahati	36 – 55 score	Moderately susceptible
2	Beka	15 – 35 score	Moderately resistant
3	Bekoji	15 – 35 score	Moderately resistant
4	EH-1847	01 – 14 score	Resistant
5	Grace	56 – 79 score	Susceptible
6	Holker	36 – 55 score	Moderately susceptible
7	Ibon-174/03	01 – 14 score	Resistant
8	Miscal-21	01 – 14 score	Resistant
9	Moeta	56 – 79 score	Susceptible
10	Traveller	01 – 14 score	Resistant

Table 4: Effects of varieties on barley scald intensity during the main cropping season of 2020.

	Degem		Wachale	
Variety	PSI	AUDPC	PSI	AUDPC
Bahati	52.36	1472.22	42.5	1191.3
Beka	28.31	802.67	16.133	452.32
Bekoji-1	26.28	751.22	11.53	328.07
EH-1847	3.44	90.77	0	0
Grace	76.827	2150.05	70.08	1942.62
Holker	49.14	1371.53	39.59	1105.65
Ibon-174/03	3.24	78.63	0	0
Miscal-21	4.34	108.97	0	0
Moeta	73.85	2074.33	73.85	2074.33
Traveller	13.04	355.37	5.37	141.17
Mean	33.08	925.57	25.90	723.54
CV (%)	4.15	4.38	4.41	4.61

Note: PSI: Percent Severity Index; AUDPC: Area Under Disease Progressive Curve.

Spike length is one of the important yield contributing components. It is directly associated with yield. It has been found that a spike with more length bears more number of grains. Therefore, any change in spike length will have a direct impact on yield. In this regard, different varieties have different capacities for adaptation of different environmental conditions, and finally, the result of yield and their components may be quite different. Current result is also in agreement with that of Shahzad who stated that the varietal difference in spike length is administered by genetic m make-up of the genotype and the environmental consequence.

A significant difference ($P<0.01$) was depicted among the varieties across the locations for TKW, which ranged from 38.5 g to 51.61 g. Maximum TKW was exerted by variety Miscal-21 (51.61 g) followed by Traveller (49.93 g), EH-1847 (49.67 g), Ibon174/03 (48.48 g), Bekoji-1 (47.94 g), Beka (45.97 g) and the lowest TKW was recorded in variety Grace (38.5 g). Thousand kernel weights is also an important character of a variety in indicating its adaptability and productivity.

Percent severity index

Percent severity index varied from 3.24 in variety Ibon-174/03 to 76.827 on Grace at Degem and no visible disease symptoms were observed in variety EH-1847, Ibon-174/03 and Miscal-21 at Wachale District. The combined mean Analysis of Variance also showed highly significant difference in PSI among varieties.

In general, scald severity had progressively increased on the malt barley varieties as they matured under field conditions. This might be due to the field conditions under which, multiple cycles of re-infection promoted greater pathogen virulence which helped to challenge the true resistance potential of a genotype.

William also reported increase in percentage of severity when the plant became older and suggested that the resistance genes to be effective only at seedling stage and not effective at adult. Similar result was reported by Maphosa, who observed that evaluating germplasm for resistance to scald at the seedling stage did not guarantee adult plant resistance. Studies by Ribeiro concluded that seedling evaluation and selection did not correlate with adult plant resistance because under field conditions the multiple cycles of re-infection plant stage of growth promoted greater pathogen virulence which challenged the true resistance potential of a genotype. This makes it ideal to evaluate varieties starting from this stage as variation in severity is greatest during later growth period.

According to Singh scale, the varieties EH-1847, Ibon-174/03, Miscal-21 and Traveller were categorized as resistant while variety Grace and Moeta were susceptible to barley scald. The rest four varieties formed intermediate groups as moderately resistant (Beka, Bekoji-1) and moderately susceptible (Bahati and Holker) [26-30].

In general, there was a good agreement in disease level across the tested varieties between the two locations. The varieties at the extremes such as the resistant varieties Ibon, Miscal-21, EH-1847 and Traveller and the susceptible varieties Grace and Moeta had similar reaction to scald regardless of experimental locations.

Area under disease progress curve

AUDPC expressed in % days (accumulation of daily percentage infection values) was significantly different (P<0.01) among the malt barley varieties tested for their reaction to scald in both locations since scald was the only disease appeared during the growing season at both sites (Figure 1A). Significantly lower AUDPC values of 78.63%, 90.77%, 108.97% and 355.37% in days were obtained from Ibon-174/03, EH-1847, Miscal-21 and Traveller varieties, respectively, while significantly higher AUDPC values of 2150.05%, 2074.33%, 1472.22% were recorded from Grace, Moeta and Bahati verities, respectively, at Degem. Whereas no visible symptoms were observed on Ibon-174/03, EH-1847 and Miscal-21 varieties, and significantly higher AUDPC values of 2074.33%, 1942.62%, 1191.3% were recorded again from Moeta, Grace and Bahati verities, respectively, at Wachale. The differences on diseases severity at two locations might be due to altitudinal differences since attitude is one factor for disease intensity.

During this study, a variation in resistance to scald disease of malt barley released varieties responded could be due to their genetic differences. Previous findings by Arabi and Liu also revealed that varied response occurred among barley lines due to genetic differences. Liu also suggested that the type and quantity of phytoalexin produced due to infection by the fungus might have caused the varied response between hosts and disease occurrence in a population of plants depending on the level of host resistance and amount of initial inoculum present. Seed born inoculum as a source of primary infections of *R. secalis* has been also reported in different studies.

Correlation between disease parameters and yield and yield related traits

The combined mean analysis of variance showed that there was significant (P<0.01) and negative correlation with thousand kernel weight and grain yield (Table 5). Disease severity had a strong and negative significant (P<0.01) correlation with thousand kernel weight (-0.94), spike length (-0.77) and grain yield (-0.69). The other disease parameter, AUDPC followed the same trend although the strength of the correlation varied depending on the parameter. The highest value of correlation coefficient indicated strong relationships between parameters. These differences could be caused by the decrease in the photosynthetic capacity (Figures 1B and 1C), leading to a decrease in the carbohydrates level in the kernel.

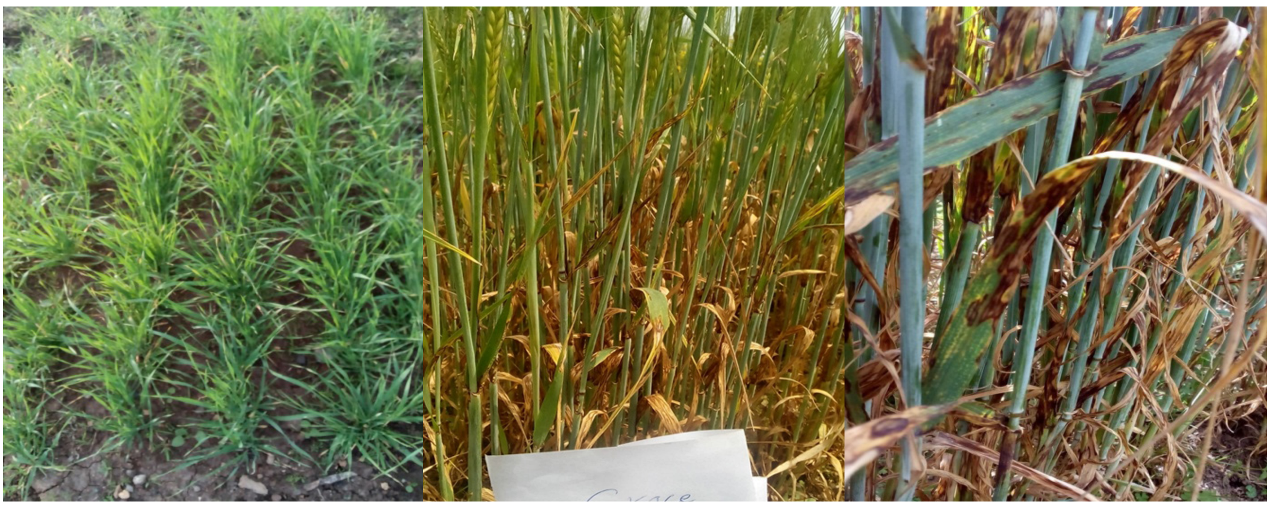

Figure 1: An overview of scald progress effect from seedling to maturity stage on susceptible grace variety: (A) Grace Variety at seedling stage (B) Grace Variety at 50% heading (C) Grace Variety near to maturity.

Table 5: Combined mean of correlation coefficient between disease parameters and yield components.

	Traits	PH	PSI	AUDPC	DH	SL	DM	TKW	GY
Traits	1								
PH	-0.26	1							
PSI	-0.062	-0.25	1						
AUDPC	-0.065	-0.255	0.999**	1					
DH	-0.089	-0.213	0.243	0.24	1				
SL	0.104	-0.236	-0.770**	-0.774**	-0.273	1			
DM	0.26	0.358*	-0.368*	-0.367*	0.087	0.147	1		
TKW	0.216	0.303	-0.945**	-0.94**	-0.17	0.648**	0.402*	1	
GY	-0.032	-0.091	-0.694**	-0.697**	-0.02	0.793**	0.169	0.601**	1

Note: *and** are level of significant different at 0.05 and 0.01, respectively. PH: Plant Height, PSI: Percentage Severity Index, AUDPC: Area Under Disease Progress Curve; DH: Days to Heading, DM: Days to Maturity; SL: Spike Length; TKW: Thousand Kernel Weight; GY: Grain Yield.

Some researchers also observed that the greatest risk to barley varieties occurred, when conducive environmental factors favoured spore dispersal during and shortly after flag leaf emergence, and the crop losses have been related to total leaf area infected including necrotic lesions and chlorotic flakes (Figure 2).

Figure 2: An overview of scald resistant Ibon-174/03 variety.

CONCLUSION AND RECOMMENDATION

The tested varieties showed significant variation for phenological, growth, yield and yield related traits. From the tested varieties, Ibon-174/03, EH-1847 and Traveller showed better performance for the evaluated traits. Highest grain yield (4415.25 kg/ha) was recorded in Traveller, whereas, the low yielder varieties were recorded from Moeta and Grace. Lower AUDPC values of 78.63%, 90.77%, 108.97% and 355.37% were obtained from Ibon-174/03, EH-1847, Miscal-21 and Traveller varieties, respectively, while higher AUDPC values of 2150.05%, 2074.33%, 1472.22% were recorded from Grace, Moeta and Bahati verities, respectively at Degem District. Whereas No visible symptoms of disease were observed in Ibon-174/03, EH-1847 and Miscal-21 varieties, but significantly higher AUDPC values of 2074.33%, 1942.62%, 1191.3% were recorded from Moeta, Grace and Bahati verities, respectively at Wachale District.

The correlation analysis of disease parameters also showed the presence of highly significant and negatively strong correlation with grain yield and thousand kernel weights. Conclusively, it is essential to select and recommend varieties that showed better performance through most of the characters studied. Accordingly, three varieties (Ibon-174/03, EH-1847 and Traveller) which showed better performance among the tested varieties were selected and recommended for study areas and similar agro-ecologies.

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DISCLOSURE STATEMENT

The authors declare that they have no conflict of interests.

ETHICAL DECLARATIONS

The research was not involving humans and animals as experimental units. The research was conducted by keeping the research ethics.

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author, (Samuel Engida), upon reasonable request.

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