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Research Article

Assessment of Seed Quality and Seed-Borne Pathogens of Barley (*Hordeum vulgare L.*) in Major Growing Areas of Ethiopia

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ABSTRACT

The study was conducted to assess seed quality and seed borne pathogen of barely seed collected from formal and informal seed sources in major growing areas of Ethiopia. By using multistage purposive sampling techniques 156 samples were collected from four major barely growing regions of Ethiopia and quality of seed samples was analyzed using standard testing procedures at Holetta seed research laboratory. Analysis result showed that highly significant ($P<0.001$) difference in physical purity, moisture content, thousand seed weight, germination percentage, seedling length, seedling dry weight, vigor index for barely seed obtained from different districts. Similarly, high significant difference ($P<0.001$) in physical purity, moisture content, thousand seed weight, germination percentage, seedling length, vigor index one for barely seed collected from different seed sources. Thirteen different types of seed borne fungal diseases were observed on barely seed collected from both sources and districts. Generally, most of barely seed collected from farmers/informal seed sources were low in seed quality and did not satisfy the minimum quality standards whereas, barely seed obtained from different seed sources (formal) met Ethiopian minimum seed quality standards. Most of the farmer did not use improve varieties so that, awareness creation or training on the impact of using improved seeds with other necessary inputs to increase seed quality, seed production, management and distribution in the country will be expected from regional, zonal and districts of agricultural experts in collaboration with agricultural research and seed quality control units.

Keywords: Barely; Districts; Seed quality; Seed health

INTRODUCTION

Barley (*Hordeum vulgare L.*) is a diploid (2n=14) plant with high degree of self-fertilization. It was a dietary mainstay of ancient civilization and continued to be an important dietary constituent in certain regions of Africa, Asia and Latin America. It can be speculated that the evolution of barley as beverages and foods paralleled the early development of the human race. Besides its dietary importance, the Western countries are using barley mainly for animal feed and alcohol production from malted barley. Ethiopia has diverse agro-ecology and cultural practices which contributed a lot to have a wide range of barley diversity. Based on the presence of higher phenotypic diversity, wild barley types and the concentration of disease resistance genes, Ethiopia is considered as a center of origin of barley [1].

From African continent, Morocco, Ethiopia, Algeria, Tunisia and Libya are the five largest barley producers with estimated production of 2.5, 2.1, 0.9, 0.5 and 0.1 million tons respectively. Smallholder farmers in the highlands of Ethiopia grow barley for various purposes including food, beverage and feed. In 2017/18 main cropping season, about 3.5 million smallholder farmers cultivated barley on 951,993 ha of land and produced 2,052,996.4 tons with average productivity of 2.16 tons/ha. It is ranked fifth after teff, maize, sorghum and wheat in the area coverage. Area allocation and amount of barley produce in Ethiopia show great variation among regions and districts. The share of Oromia and Amhara regions in both area coverage and production is the largest. CSA data (2018) revealed that these two regions accounted about 81.43 percent of area coverage and 84.17 percent of total barley production. High quality seed of improved crop varieties are the most cost-effective way of increasing crop production and productivity. Quality seed must primarily healthy, genetically and physically pure, and viable and vigor, contain proper moisture level and should be free from pathogens. These are quality criteria for seed at local and global scale. The criteria provide clue for the planting value of a seed lot produced by different seed growers. Using improved seeds

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in crop production could contribute to increase the productivity and production from which farmers and seed producers can highly benefit. However, supply of improved seed has always been shorter than yearly demand by farmers. Promotion and development of informal seed production could make considerable contribution to village/local seed supplies. Moreover, quality of seeds produced by the farmer is a matter of concern. There is no clearly documented information on seed borne pathogen for formal and informal seed system in Ethiopia case and it is scanty. Therefore, this work was carried out to assess and document the current status of seed-borne pathogens of barley crop collected from formal and informal seed sources in major growing areas of Ethiopia [2-4].

MATERIALS AND METHODS

Sampling areas

Each farmer and seed producer was interviewed using a structured and open-ended questionnaire. Moreover, a sample of 1000 g seed was drawn from the farmers seed lot planted or intended for planting for seed quality analysis in the laboratory. From Oromiya and Amhara regional state five districts and eight farmers from each, from South nation and nationality regional state three districts and eight farmers from each district and from Tigray regional state two districts and eight farmers from each district were used for sampling [5,6].

Samples were also collected from seed producers namely, Ethiopian seed enterprise, Oromiya seed enterprise, Amhara seed enterprise, kulumissa agricultural research center, Sinana agricultural research center, Deber birhan agricultural research center, wodera cooprative union, Gondar agricultural research center, Adet agricultural research center, Mekele agricultural research center, Alamata agricultural research center, Sirika agricultural research center and worabe agricultural research center of the country [7].

Data collection

Physical purity test: A sample of 1 kg from each source was well mixed and reduced to sub-sample (working sample) of 120 g using mechanical seed divider. Four replicates of 60 g were divided into four fractions (pure seed, other crop seed, weed seed and inert matter) and analyzed. After analysis, the percentage of each fraction (based on weight) was calculated as follows:

$$\text{Purity}\ (\%) = \frac{\text{Weight of Pure Seed}}{\text{Weight of Total sample}} \times 100$$

Moisture content: Moisture content was determined by using the indirect moisture testing meter HE light following international rules for seed testing [8].

Thousand seed weight: Thousand seed weight was determined by counting thousand seed by seed counter from pure seed fraction in four replicates of 1000 seed and the average seed weight was calculated.

Standard germination test: Standard germination test was done by using Four hundred (400) seeds were randomly taken from mixed pure seed and divided in to four replicates of 100 seeds each. The seeds were sown in sterilized sand medium and kept in Seed germinator at room temperature [9]. The first count was done on 4th day after planting for and final count was done on 8th day. Seedling was evaluated in to normal, abnormal. Seedling, Hard and dead seed. The standard germination was calculated in percentage (ISTA, 1996) as follow:

$$\text{Germination}\ (\%) = \frac{\text{Total Number of Normal Seedling}}{\text{Total Number of Seeds Planted}} \times 100$$

Shoot and root length: The seedling shoot length and seedling root length were assessed after the final count in the standard germination test. Ten normal seedlings were randomly selected from each replicate. The shoot length was measured from the point of attachment to the cotyledon to the tip of the seedling. Similarly, the root length was measured from the point of attachment to the cotyledon to the tip of the root. The average shoot or root length was computed by dividing the total shoot or root lengths by the total number of normal seedlings measured [10].

Seedling dry weight: The seedling dry weight was measured after the final count in the standard germination test. Ten seedlings randomly selected from each replicate were cut free from their cotyledons and placed in envelopes and dried in an oven at 80°C ± 1°C for 24 hours. The dried seedlings were weighed to the nearest milli-gram and the average seedling dry weight was calculated.

Vigor index test: The seedling vigor index was calculated for each sample as per Abdul Baki and Anderson and expressed in number by using formula below. Seedling vigor index 1 was calculated by multiplying the standard germination with the average sum of shoot length and root length after 8 days of germination and vigor index 2 was again calculated by multiplying the standard germination with mean seedling dry weight (drying at temperature of 80°C for 24 hours). The formula for these parameters: SVI1=Standard germination × mean seedling length (Roots+Shoots length) SVI2=Standard germination × mean seedling dry weight [11-13].

Seed health testing: Fifty seeds, 5 replicates from each sample were planted in germination boxes using a blotter paper (pleated paper) moistened by distilled water and incubated in a germinator for 24 hours at 20°C for seed to imbibe water. The seeds were incubated at 20°C for 7 days with near UV light in alternating cycles of 12 hours' light and 12 hours' darkness to stimulate sporulation. Examination of seeds was carried out after 7 days of incubation under a stereoscope microscope. The infected seedlings were counted and the pathogens were identified based on morphological traits including colony features, structures, and spores using stereo- and compound-microscopes [14-17].

$$\text{Seed Infection}\ (\%) = \frac{\text{Number of infected seed}}{\text{Total number of seed}} \times 100$$

Data analysis

Statistical analysis system (SAS version 9.3) software of the General Linear Model (GLM) procedure was applied to calculate seed quality data and mean comparisons among treatments were done using the Tukey's Studentized Range (HSD) test at 5% level of significance [18-21].

RESULTS AND DISCUSSION

Descriptive statistics analysis

Multistage purposive sampling techniques were used to collect a total of 156 samples from four major barely growing regions of the country. From Amhara regional state 61 samples, Oromiya regional state 41 samples, South nation and nationality regional state 26 and Tigray regional state 28 samples were collected. From Table 1 the highest sample percent (39.1%) were shared by Amhara regional state followed by Oromiya regional state (26%) whereas the lowest percent was shared by South nation nationality and peoples of Ethiopia (SNNPE) (16.7%). The highest (112) number of seed sample were collected from farmer this group shares about (71.8%) whereas, the lowest seed sample were obtained from union which shares 0.6 percent (Table 2) [22,23].

Table 1: Percentage sharing of sample taken from each region.

Region	Frequency	Percent
Tigraye	28	17.9
Amhara	61	39.1
Oromiya	41	26.3
SNNPE	26	16.7
Total	156	100.0

Table 2: Proportion of seed source.

Seed Source	Frequency	Percent
Farmer	112	71.8
Research Center	35	22.4
Seed Enterprise	8	5.1
Union	1	0.6
Total	156	100.0

Source: From survey study, 2019.

Laboratory test

Physical and physiological seed quality: Physical purity and physiological quality (vigour) of barely seed samples was presented for different districts (Table 3) and different sources (Table 4). The results of physical purity and physiological quality of barely seed collected from different districts showed high variation (P<0.001). Only 55.33% (n=15) for physical purity 26.67% (n=15) for moisture content and 60% (n=15) for germination met the Ethiopian seed quality standards for barely seed obtained from different districts. The highest physical purity was observed for limu (97.74%), limuna bilibilo (97.59%), masikal (97.53%), Ambalge (97.09%) and Debarki (96.89%) districts whereas; the lowest analytical purity was recorded for Senana districts (87.23%).

Mean moisture content level ranged from the lowest in Debarki (10.96%) to the highest in Duyo Gena (15.23%). The highest thousand seed weight was recorded for Lay Gayint district (50.49 g) whereas the lowest was observed for sinana district (41.24 g). The overall mean germination was 87% with a range from 67% to 99% the highest germination percentage was recorded for Umo (99%), Dodolla (97%) and Tiyo (97%) whereas; the lowest was recorded for Sinana district (67%). The physiological quality of seed obtained from different geographic regions may vary because of the environmental effects during the formation, development and maturation of seed. Grass and Burris found that environmental factors such as high temperature had variable effect on germination.

On the other hand, the highest shoot length was recorded for masikal district (15.52 cm) whereas, the lowest shoot length was observed for Senana district (9.83 cm). The highest seedling dry weight was recorded for dodolla district (312.50 milligram) followed by masikal district (278.75 milligram) and limuna bilibilo district (277.50 milligram) whereas the lowest was observed for farta district (145 milligram). The highest vigour index 1 was recorded for masikal (2787.25) and Basona worana district (2761.44) whereas the lowest was recorded for Sinana district (1647.83). Similarly, the highest vigor index 2 was recorded for dodolla district (30479) whereas; the lowest was recorded for farta district (12579). The results of physical purity and physiological quality of barely seed collected from different seed source showed high significant difference (P<0.0001) for purity%, Moisture content, thousand weight, Standard germination%, Shoot length, Root length and Vigor index one and non-significance difference was observed for Seedling dry weight and Vigor index two (Table 6). 100% (n=13) for physical purity 85% (n=13) for moisture content and 100% (n=13) for germination met the Ethiopian seed quality standards for barely seed obtained from different seed sources. The highest Physical purity percent was recorded for wodera cooperative union (100%) followed by Ethiopian seed enterprise (99.83%) whereas the lowest was observed for adet agricultural research center (96.46%). The lowest moisture content was recorded for samples collected from Gonder (11.74%) and Adet (11.80%) agricultural research center whereas the highest was recorded for kulumessa agricultural research center (13.93%). The highest thousand seed weight was recorded for wodera cooperative union (51.55 g) and the lowest was recorded for mekele agricultural research center (11.91 g). On the other hand, the highest (100%) germination percentage was recorded for oromiya agricultural research center and wodera cooperative union whereas the lowest (91%) was observed for Deber Birhan research center (91%). Woldeselassie also found a very significant variation in germination of barley seed collected from different regions and sources. It was noted that the unusually extended rainfall during crop maturity and at harvesting time contributed to loss of physiological quality of seed due to pre-harvest sprouting. In hard red wheat, indicated that sprouting was highly correlated with reduced germination before and after accelerated aging and reduced emergence from deep planting, but not with field emergence and yield. It was concluded that wheat seed damaged due to incipient sprouting could be used with caution within a year and under normal planting conditions. The highest shoot length (15.92 cm) was recorded for worabe agricultural research center whereas the lowest (11.65 cm) was recorded for Adet agricultural research center. Similarly, the highest root length was recorded for Deber birhan research center (16.19 cm) and the lowest root length was recorded for adet research center (11.08 cm) (Table 4). Commonly those seedlings produced longer shoots and roots were from vigor seeds. It is assumed that seedlings with well-developed shoot and root systems would withstand any adverse conditions and provide better seedling emergence and seedling establishment in the field as reported. The highest vigor index 1 was recorded for wodera cooperative union (2950.05) and worabe research center (2903.24) and the lowest was recorded for adet agricultural research center (2222.50) and gonder agricultural research center (2263.43) mainly because of low shoot and root length.

Table 3: Average mean of physical purity and physiological quality (vigor) of barely seed collected from major barely growing districts of Ethiopia.

Districts	Purity (%)	MC (%)	TSW (%)	SG (%)	SL (cm)	RL (cm)	SDW (mg)	VI1	VI2
Tiyo		14.19bc	44.63efgh	97a	12.11ef	11.36de	205.00de	2287.30c	19958cde
Limuna bilibilo	97.59a	13.18d	47.78abcd	95ab	11.87ef	11.92cd	260.00bc	2260.70c	24741bc
Sinana	95.86ab	13.27d	41.24i	67g	12.38de	11.94cd	277.50ab	1647.83e	18617de
Dodolla	95.54ab	13.50cd	42.25ghi	97a	13.30cd	12.11cd	312.50a	2503.09b	30479a
Duyo Gena	96.08ab	15.23a	50.41ab	80f	11.37fg	10.65ef	240.00bcd	1848.21d	19145de
Umo	92.84abc	14.29b	47.49bcde	99a	13.71bc	11.25de	235.00bcd	2460.09b	23156bcd
Limu	97.74a	14.19bc	45.88cdef	83ef	14.03bc	12.19cd	242.00bcd	2188.06c	20143cde
Masikal	97.53a	12.02de	41.75hi	94ab	15.52a	13.17b	278.75ab	2787.25a	28195ab
Ofla	90.31bc	14.33b	44.26fgh	78f	11.33fg	12.12cd	202.50de	1953.09d	15773efg
Ambalage	97.09a	12.82de	45.15defg	81f	13.44c	13.18b	210.00cd	2246.92c	16951efg
Basona worana	93.70ab	12.27e	42.97fghi	91bcd	14.63ab	14.74a	216.25cd	2761.44a	19716de
Lay Gayint	92.52abc	13.02de	50.49a	88cde	12.45de	12.51bc	200.00de	2206.66c	17582ef
Farta	93.09ab	12.27e	41.99hi	87de	13.79bc	11.83cd	145.00f	2230.27c	12579g
Debarki	96.89a	10.96f	42.19hi	81f	10.52gh	9.47g	157.00ef	1799.93de	12736fg
Senana	87.23c	14.43b	48.17abc	93abc	9.83h	10.00fg	209.25cd	1861.57d	19453de
Mean	94.7	13.4	45.11	87	12.7	11.9	226	2203	**
Tukey's HSD	5.83**	0.79**	2.96**	5.7**	0.94**	0.97**	51.74**	171.92**	4937.90**
CV (%)	4.32	4.13	4.59	4.56	5.19	5.73	16	5.47	17.5

Note: ** indicate highly significant at 5% level of probability. *Means in the same column followed by similar letters are not significantly different from each other at 5% level of probability. MC: Moisture Content; TSW: Thousand Seed Weight; SG%: Standard Germination Percentage; SL: Shoot Length; RL: Root Length; SDW: Seedling Dry Weight; VI1: Vigor Index One; VI2: Vigor Index Two.

Table 4: Average mean of physical purity and physiological quality (vigor) of barely seed collected from different sources in Ethiopia.

Seed Source	Purity (%)	MC (%)	TSW (%)	SG (%)	SL (cm)	RL (cm)	SDW (mg)	VI1	VI2
Kulumssa Agricultural Research Center	99.59ab	13.93a	40.72f	99abc	14.19cd	12.82de	235.00ab	2686.39b	23268abc
Sinana Agricultural Research Center	96.71ef	12.09d	47.72bc	98bc	13.09f	12.04ef	262.50a	2464.82d	25760a
Worabe Agricultural Research Center	98.51abcd	12.95b	47.02c	99abc	15.92a	13.36cd	205.00b	2903.24a	20324bcd
Debrebirhan Agricultural Research Center	98.06bcdef	12.09d	46.03d	91.00h	15.22b	16.19a	208.00b	2865.78a	18918cd
Sirika Agricultural Research Center	98.31abcde	12.63c	40.78f	96e	13.73de	13.36cd	237.50ab	2495.58cd	22779abcd
Gonder Agricultural Research Center	98.37abcde	11.74e	44.31e	96de	12.09gh	12.20ef	240.00ab	2263.43f	23108abc
Adet Agricultural Research Center	96.46f	11.80e	47.55bc	98cd	11.65h	11.08g	222.50ab	2222.50f	21787abcd
Alamata Agricultural Research Center	97.71cdef	13.03b	40.74f	92gh	13.44ef	13.08cd	214.00ab	2447.82d	19767bcd
Mekele Agricultural Research Center	97.77cdef	11.91de	40.47f	93g	14.39c	13.72bc	195.00b	2626.06b	18156d
Ethiopian Seed Enterprise	99.83a	12.99b	43.51e	94fg	14.16cd	11.67fg	235.00ab	2418.44de	22035abcd
Oromia Seed Enterprise	99.38abc	12.98b	47.72bc	100a	13.22ef	12.78de	242.50ab	2593.33bc	24194ab
Wodera Cooperative Union	100.00a	12.85bc	51.55a	100a	15.25b	14.40b	220.00ab	2950.05a	21903abcd
Amhara Seed Enterprise	97.11def	12.83bc	48.32b	95ef	12.51g	11.89fg	226.50ab	2312.95ef	21447abcd
Mean	98.29	12.6	45.11	96.2	13.76	12.97	226.4	2558	**
Tukey's HSD	1.73**	0.28**	0.99**	1.60**	0.54**	0.86**	49.45NS	110.23**	4861.80NS
CV	1.22	1.57	1.53	1.16	2.73	4.64	15.23	3.01	16

Note: ** indicate highly significant at 5% level of probability. *Means in the same column followed by similar letters are not significantly different from each other at 5% level of probability. MC: Moisture Content; TSW: Thousand Seed Weight; SG%: Standard Germination Percentage; SL: Shoot Length; RL: Root Length; SDW: Seedling Dry Weight; VI1: Vigor Index One; VI2: Vigor Index Two.

Table 5: Mean percentage of seed borne pathogen associated with barely seed collected from different district.

Districts	Foxy	Fmon	Fgram	Botry	Bvic	Bsor	Penci	Alt	Afl	Anig	Tind	Clad	Rhiz	SC%
Tiyo	0.00	0.00	0.00	0.00	0.00	0.00	2.00	4.00	12.00	0.00	0.00	0.00	6.00	24.00
Limuna bilibilo	2.00	6.00	0.00	0.00	0.00	0.67	0.00	4.67	12.67	0.00	0.00	2.00	8.67	36.67
Sinana	0.50	0.75	0.00	0.00	0.00	0.00	5.00	0.00	23.25	0.00	0.00	0.00	12.75	42.25
Dodolla	0.00	1.11	0.00	0.00	0.00	0.00	10.89	1.78	13.33	0.00	0.00	0.00	16.22	43.33
Duyo Gena	0.00	1.20	0.00	0.00	1.50	0.00	3.00	0.00	6.00	0.00	0.00	3.00	5.00	19.70
Umo	0.00	2.00	0.00	0.00	0.00	0.00	6.00	3.00	18.00	0.00	0.00	0.00	10.00	39.00
Limu	0.00	4.00	0.00	0.00	0.00	0.00	12.00	6.00	36.00	0.00	0.00	0.00	20.00	78.00
Masikal	0.00	8.00	0.00	0.00	0.00	0.00	24.00	12.00	72.00	0.00	0.00	0.00	40.00	100.00
Ofla	0.00	8.00	0.00	0.00	0.00	0.00	24.00	12.00	72.00	0.00	0.00	0.00	40.00	100.00
Ambalage	0.80	0.00	0.00	0.00	0.00	0.00	4.00	4.00	7.20	0.00	0.80	0.80	12.80	30.40
Basona worana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	40.00	45.00
Lay Gayint	1.33	0.67	0.00	0.00	0.00	0.44	0.89	2.89	10.89	0.44	0.00	0.00	2.89	20.44
Farta	0.00	0.00	0.00	0.00	0.00	0.00	6.00	2.00	15.60	0.00	0.00	1.20	14.80	39.60
Debarki	0.00	0.00	0.00	0.00	0.00	0.00	4.00	6.00	10.00	0.00	0.00	0.00	10.00	30.00
Senana	0.00	3.50	0.00	0.00	0.00	0.00	5.50	4.25	15.50	0.00	0.00	0.00	17.50	46.25

Note: Foxy: *Fusarium oxysporium*; Fmon: *Fusarium monoliformae*; Fgram: *Fusarium graminaerum*; Botry: *Botrytis* sp; Bvic: *Bipolaris victorae*; Bsor: *Bipolaris sorokiniana*; Penci: *Penicillium* sp; Alt: *Alternaria* sp; Afl: *Aspergillus flavus*; Anig: *Aspergillus niger*; Tind: *Tilletian indica*; Clad: *Cladosporium* sp; Rhiz: *Rhizopus* sp; SC%: Seed Contamination Percentage/Disease Incidence.

Table 6: Mean percentage of seed borne pathogen associated with barely seed collected from different sources.

Name of seed producer	Foxy	Fmon	Fgram	Botry	Bvic	Bsor	Penci	Alt	Afl	Anig	Tind	Clad	Rhiz	SC%
Kulumssa Agricultural Research Center	0.00	0.00	0.00	0.00	0.00	0.00	16.57	0.00	20.57	0.00	0.00	0.00	30.29	67.43
Sinana Agricultural Research Center	0.00	0.00	0.00	0.00	0.00	0.00	33.14	0.00	41.14	0.00	0.00	0.00	60.57	100.00
Worabe Agricultural Research Center	33.00	9.00	5.25	0.00	0.00	5.75	8.75	0.00	29.00	5.75	0.00	5.75	39.00	100.00
Debrebirhan Agricultural Research Center	41.25	6.50	5.00	0.00	0.00	1.25	22.00	0.00	34.50	5.50	0.00	0.00	38.75	100.00
Sirika Agricultural Research Center	27.50	0.00	0.00	16.75	0.00	0.00	7.50	0.00	26.75	0.00	0.00	7.00	37.25	100.00
Gonder Agricultural Research Center	3.25	1.00	2.75	14.50	0.75	0.00	9.75	3.75	11.25	5.00	0.00	4.75	14.00	70.75
Adet Agricultural Research Center	10.50	0.00	2.50	10.75	3.00	7.00	2.50	7.00	18.50	0.75	9.75	3.75	15.50	91.50
Alamata Agricultural Research Center	12.00	3.33	10.67	2.67	7.33	4.67	4.00	9.33	11.33	0.00	0.00	0.00	27.33	92.67
Mekele Agricultural Research Center	0.00	0.00	0.00	8.00	0.00	0.00	8.00	15.00	52.00	0.00	0.00	0.00	45.00	100.00
Ethiopian Seed Enterprise	7.00	0.00	8.00	1.33	4.00	4.00	4.33	9.67	36.67	2.33	0.00	3.00	22.33	100.00
Oromia Seed Enterprise	2.67	2.67	6.00	0.00	4.00	5.33	0.00	10.00	42.67	0.00	0.00	4.67	15.33	93.33
Wodera Cooperative Union	3.75	1.00	1.50	3.00	0.00	0.00	19.50	1.75	42.75	0.00	0.00	0.00	30.75	100.00
Amhara Seed Enterprise	7.33	4.67	9.33	10.00	0.00	0.00	23.33	16.67	38.00	0.00	0.00	0.00	33.33	100.00

Note: Foxy: *Fusarium oxysporium*; Fmon: *Fusarium monoliformae*; Fgram: *Fusarium graminaerum*; Botry: *Botrytis* sp; Bvic: *Bipolaris victorae*; Bsor: *Bipolaris sorokiniana*; Penci: *Penicillium* sp; Alt: *Alternaria* sp; Afl: *Aspergillus flavus*; Anig: *Aspergillus niger*; Tind: *Tilletian indica*; Clad: *Cladosporium* sp; Rhiz: *Rhizopus* sp; SC%: Seed Contamination Percentage/Disease Incidence.

Seed health testing

Several seed-borne fungi, including species of the genera *Fusarium*, *Alternaria*, *Aspergillus* and *Penicillium* have been considered as important pathogens of cereal grains. Seed borne mycoflora is one of the major components reducing the barely yield. Mycoflora associated with seeds both internally and externally are responsible for seed abortion, mortality of grains, reduction in germination capacity, seed necrosis and at the end cause destructive to serious diseases during different stages of plant growth. Yield losses due to seed borne fungi have been

reported between, 15% to 90% of untreated seeds grown in field. Seed borne pathogens of barley include *Alternaria alternata, Cladosporium oxysporum, Curvularia lunata, Drechslera sorokiniana, D.tetramera, Fusarium graminearum, Helminthosporium sativum*, and post-harvest fungi include species of *Aspergillus* and *Penicillium*. Genera of *Fusarium, Alternaria, Drechslera, Stemphylium, Curvularia, Cladosporium, Rhizopus, Aspergillus* and *Penicillium* have been the most common isolated fungi from Barley seeds. For the management of crop disease, the major step is to use disease free and certified seed. The study showed that thirteen different types of seed borne fungal diseases were observed on barely seed collected from different sources/formal and districts/informal (Tables 5 and 6).

All the samples tested for districts were associated with at least one known pathogen. The fungal genera and species associated with the barely seed samples were *Fusarium oxysporium, Fusarium monoliformae, Fusarium graminaerum, Botrytis* sp, *Bipolaris victorae, Bipolaris sorokiniana, Penicillium* sp, *Alternaria* sp, *Aspergillus flavus, Aspergillus niger, Tilletian indica, Cladosporium* sp and *Rhizopus* sp. This result is consistent with previous reports on barley who reported that *Alternaria, Aspergillus, Cladosporium. Epicoccum, Fusarium, Helminthosporium, Penicillium, Trichoderma, Trichothecium* spp. and *Ustilago hordei* were detected from farmer saved barely seed. The result is also consistent with who detected those are *Helmithosporium sativum, Helmithosporium teres, Fusarium graminarum, Fusarium Oxysporium, Fusarium avenacerum, Cladosporium* sp, *Alternaria* sp, *Botryo diplodia, Phoma, stemphylium, Pencillium, Trichoderma, Aspergillus* sp and *Chaetomium* different types of seed borne pathogen on barely crops.

From Table 5 the highest seed contamination percentage of seed borne fungi was detected for masikal districts (100%) followed by limu bilibilo districts (78%). The disease incidence difference might be due to differences in moisture content and seed management including differences in seed storage conditions. Concerning the individual pathogen at each district the highest percent of Fusarium oxysporium was observed for limuna bilibilo districts (2%) whereas the lowest was observed for Sinana district (0.5%). On the other hand, the highest percent of *Fusarium monoliformae* was observed for masikal district (8%) whereas; the lowest was recorded for lay gayint district (0.67%). Out of thirteen districts *Fusarium graminaerum* and *Botrytis* sp was observed for ofla district which is about 1% and 1.5% respectively on the other hand about 1% and 0.5% of *Bipolaris victorae* was observed only for Duyo Gena and ofla districts respectively. Similarly, *Bipolaris sorokiniana* was observed only for ofla (0.75%), Lay Gayint (0.44%) and limuna bilibilo districts (0.67%).

The highest percent of *Penicillium* sp (24%), *Alternaria* sp (12%) and *Aspergillus flavus* was recorded for masikal district on the other hand, the lowest percent of diseases *Penicillium* sp (0.89%), *Alternaria* sp (1.78%) and *Aspergillus flavus* (5%) were recorded for Lay Gayint, Dodolla and Basona worana districts respectively. *Aspergillus niger* was observed for only ofla (0.5%) and lay Gayint (0.44%) whereas *Tilletian indica* (0.8%) was observed only for Ambalage district. *Cladosporium* sp 2%, 3%, 0.80% and 1.20% were only recorded for Limuna bilibilo, Duyo Gena, Ambalage and Farta districts respectively. Last but not least the highest *Rhizopus* sp was recorded for Basona worana (40%) and Masikal (40%) districts were as the lowest was recorded for ofla districts.

From Table 6 contamination percentage of seed borne fungi for most of the seed collected from different seed producers were hundred percent (100%) infected by seed borne pathogen. The highest percentage infection of Fusarium oxysporium was recorded for Debrebirhan Agricultural Research Center (41.25%) and the lowest was recorded for Oromia Seed Enterprise (2.67%) on the other hand, the highest percentage infection of *Fusarium monoliformae* was observed for Worabe Agricultural Research Center (9%) whereas the lowest was recorded for Gonder Agricultural Research Center (1%) and Wodera Coopirative Union (1%). The highest percentage infection of *Fusarium graminaerum* was recorded for Alamata Agricultural Research Center (10.67%) followed by Amhara Seed Enterprise (9.33%) whereas; the lowest was recorded for Wodera Cooperative Union (1.5%). The highest *Botrytis* sp and *Bipolaris victorae* were recorded for Sirika Agricultural Research Center (16.67%) and Alamata Agricultural Research Center (7.33%) respectively whereas; the lowest *Botrytis* sp and *Bipolaris victorae* infection were recorded for Ethiopian Seed Enterprise (1.33%) and Gonder Agricultural Research Center (0.75%). The highest *Bipolaris sorokiniana* (7%) and *Penicillium* sp (33.14%) was recorded for Adet and Sinana Agricultural Research Center respectively whereas, the lowest *Bipolaris sorokiniana* (1.25%) and *Penicillium* sp (2.5%) was recorded for Debre Birhan and Adet Agricultural Research Center respectively. Highest percent (16.67%) of *Alternaria* sp was recorded for Amhara Seed Enterprise followed by Mekele Agricultural research center (15%). whereas the lowest was observed for Wodera Cooperative Union (1.75%).

The highest (52%) *Aspergillus flavus* was recorded for mekele agricultural research center whereas, the lowest were observed for Gondar (11.25%) and Alamata research center (11.33%). On the other hand, the highest *Aspergillus niger* (5.75%) and (5.50%) is recorded for Worabe and Debre birhan agricultural research center respectively. *Tilletian indica* is observed only for Adet agricultural research center (9.75%) also the highest *Cladosporium* sp (7%) and *Rhizopus* sp (60%) were recorded for Sirika and Sinana agricultural research center respectively whereas, the lowest *Rhizopus* sp were observed for oromiya seed enterprise (15.33%) followed by Adet research center (15.50%). On the other hand, the lowest (3%) *Cladosporium* sp were recorded for Ethiopian seed enterprise.

Correlation coefficients between disease incidence with physical and physiological seed quality of barely collected from different districts and sources: Correlation analysis between disease incidence and the other seed quality parameters showed that highly significant associations were observed between shoot length, seedling dry weight and vigor index one and significant association were observed among purity percentage, thousand seed weight, root length and vigor index two for seed collected from different districts/farmers. However, non-significant associations were observed among moisture contents and standard germination with that of disease incidence (Table 7). Strongly positive correlations were observed between disease incidence with shoot length (r=0.57) and positive association were observed with root length (r=0.27), seedling dry weight (r=0.34), vigor index one (r=0.44) and vigor index two (r= 0.37). Significantly negative correlation was observed among purity (r = -0.05) and thousand seed weight (r= -0.31) with disease incidence for barely seed collected from different districts.

Similarly, there were significant correlations between disease incidence percentage with that of thousand seed weight and shoot length. On the other hand, non-significant associations were observed among purity, moisture content, standard germination, root length, seedling dry weight, vigor index one and vigor index two with disease incidence for barely seed collected from different sources (Table 8). Positive association were observed among thousand seed weight (r=0.32) and shoot length (r=0.33) with disease incidence percentage for seed collected from different sources.

Table 7: Correlation coefficients(r) between disease incidence with physical and physiological seed quality of barely collected from different districts.

	Purity	MC	TSW	SG	SL	RL	SDW	VI1	VI2	DI%
Purity										
MC	0.66**									
TSW	0.53**	0.65**								
SG	0.39**	0.23 NS	0.33**							
SL	0.25**	-0.02NS	-0.11*	0.32*						
RL	0.30NS	0.01 NS	0.01 NS	0.19NS	0.79**					
SDW	0.08NS	0.26 *	-0.05NS	0.11 NS	0.19 NS	0.15 NS				
VI1	0.19NS	-0.03 NS	-0.003 NS	0.72**	0.81**	0.72**	0.18 NS			
VI2	0.20NS	0.29 NS	0.07 NS	0.52**	0.29*	0.19 NS	0.90**	0.46**		
DI%	-0.05*	-0.08 NS	-0.31*	0.18 NS	0.57**	0.27*	0.34**	0.44**	0.37*	

Note: NS **and * indicates non-significant, highly significant at 1% and significant at 5% level of probability respectively. MC: Moisture Contents; TSW: Thousand Seed Weight; SG: Standard Germination; SL: Shoot Length; RL: Root Length; SDW: Seedling Dry Weight; VI1: Vigor Index 1; VI2: Vigor Index 2; DI: Disease Incidence Percentage.

Table 8: Correlation coefficients(r) between disease incidence with physical and physiological seed quality of barely collected from different sources.

	Purity	MC	TSW	SG	SL	RL	SDW	VI1	VI2	DI%
Purity										
MC	0.38**									
TSW	-0.04NS	-0.12 NS								
SG	0.18 NS	0.27 NS	0.45**							
SL	0.26 NS	0.33*	0.00 NS	-0.05						
RL	0.16 NS	-0.03 NS	-0.02 NS	*-0.29	0.69**					
SDW	0.17 NS	-0.00 NS	0.06 NS	0.26 NS	-0.28*	-0.23 NS				
VI1	0.30*	0.29*	0.18 NS	0.16 NS	0.91**	0.80**	-0.21 NS			
VI2	0.19 NS	0.04 NS	0.14 NS	0.43**	-0.27NS	-0.27NS	0.98**	-0.16 NS		
DIP	-0.14 NS	-0.19 NS	0.32*	-0.24 NS	0.33*	0.22 NS	-0.14 NS	0.23 NS	-0.17 NS	

Note: NS **and * indicates non-significant, highly significant at 1% and significant at 5% level of probability respectively. MC: Moisture Contents; TSW: Thousand Seed Weight; SG: Standard Germination; SL: Shoot Length; RL: Root Length; SDW: Seedling Dry Weight; VI1: Vigor Index 1; VI2: Vigor Index 2; DI: Disease Incidence Percentage.

CONCLUSION

A survey was conducted at four major barely growing regions of Ethiopia with the objective of assessing seed quality and seed-borne pathogens of barley collected from formal and informal seed sources in major growing areas of Ethiopia. A total of 156 samples were randomly collected from major barely producing farmers and seed producers of the country by using multistage purposive sampling techniques. The highest (112) seed sample were taken from farmer this group shares about (71.8%). About thousand gram of seed sample was drawn from the farmers and seed producers seed lot intended for planting for seed quality analysis in laboratory.

Laboratory result showed that highly significant difference was observed for physical and physiological quality of barely seed collected from different districts of the country. Also, highly significance difference was observed for physical purity thousand seed weight, moisture content, standard germination, shoot length, root length and vigor index one and non-significant difference was observed for seedling dry weight and vigor index two for barely seed collected from different seed sources. Concerning seed borne pathogen about thirteen different types of seed borne pathogen were associated with barely seed samples collected from farmers and seed producers. The fungal genera and species associated with the barely seed samples were *Fusarium oxysporium*, *Fusarium monoliformae*, *Fusarium graminaerum*, *Botrytis* sp, *Bipolaris victorae*, *Bipolaris sorokiniana*, *Penicillium* sp, *Alternaria* sp, *Aspergillus flavus*, *Aspergillus niger*, *Tilletian indica*, *Cladosporium* sp and *Rhizopus* sp. Contamination percentage by seed borne pathogens are higher for barely seed sample collected from different seed sources than barely seed collected from farmers. At least one known seed borne pathogen were identified on barely seed collected from both farmers

and seed producers. Barely seed collected from seed source is better in physical and physiological seed quality as compared to barely seed collected from farmers. In conclusion most of barely seed collected from informal seed sources/farmers did not satisfy the minimum quality standards and most of the seed sample obtained from formal/ different sources met Ethiopian minimum seed quality standards at laboratory analysis. From the result of this study the following points are recommended. According to this study most of the farmers did not know about seed borne pathogen of barely crops and they also did treat the seed before they use for planting like other crops such as maize etc. According to the present results most of the farmers did not mange or treat their barely crops field for seed production like other crops this all have great impact on reduction on seed quality of this crops so that, adequate training will be expected from regional, zonal and district agricultural experts in collaboration with agricultural research and seed quality control units on aspects of quality seed production, management and distribution in the country.

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