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The Effect of Barley (*Hordeum vulgare* L.) Seed Source on Quality, Yield and Yield Component in Tigray, Ethiopia

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Abstract: The objective of this study was to illustrate the performance of different seed qualities of barley varieties for yield and related traits. It was conducted in four locations of southern, southeastern and eastern zone of Tigray during 2018 meher (June-October) main cropping season at farmers' field. Three farmers sourced and three C1 improved varieties of barley were tested in randomized complete block design using four replications. The barley seeds with C1 class were obtained from seed producing cooperatives and farmer source were collected from surrounding farmers. The presence of significant variations among the tested varieties for most plant characters indicated that there is variability among the tested varieties. Significant variation in plant height and spike length was observed among varieties in the study locations and taller was recorded with both Felamit and Fetina and the shortest in HB1307 whereas the taller spike length was observed with Fetina and Felamit. Mean value of total tillers and spikelet per spike showed significant different due to main effect of variety and maximum was recorded inFetina and HB1307 for tillers but maximum spikelet was recorded in Felamit. Significant different in mean thousand seed weight, economic and biomass yield was observed and maximum economic yield was recorded in HB1307. The higher mean thousand seed weight was recorded across all locations except at Hagereselam. Mean significant different was observed with straw yield and harvest index and statistical on par straw yield was observed among varieties in all locations whereas maximum harvest index was seen with HB1307 in study location. No variation was detected statistically on barley yield due to main effect of seed quality. This study indicated that prevailed of favorable growing conditions during the experimental season has contributed for equivalent performance of growing varieties across all locations regardless of seed quality. The result indicated that additional minimum improvement should be essential for barley yield and related traits. Therefore, attention should be given for further exploitation of genetic variability for varietal improvement to enhance better yield and ensured food security.

Key words: Variety · Location · Seed quality and performance

INTRODUCTION

Background: Barley is the most important crop worldwide for its wide range of environmental adaption and able to produce from temperate zone to tropical highlands [1]. Barley is the fifth most important crop in Ethiopia next to maize, tef, sorghum and wheat respectively [2]. The grain is used for preparation of different food stuffs such as roasted grain, flat bread, porridge, malting beer and different local drinks [3]. It is economically most important crop and served as a daily meal in highlands of Ethiopia. The crop covers 0.95 million hectares which was 7.7% of the total area allotted to cereal production [4]. Though, the crop covers larger area, the quality produce and productivity is very low compared to average yield of national standards in Ethiopia. It is the most neglect crop in research and only few improved varieties are available under production. The area grown by food barley in the country is still predominantly covered by farmers' varieties and farm saved seeds due to availability and access constraints of quality seeds.

Tigray is endowed with suitable agro-ecology for barley production butthe potential was not exploited so far to enhance production. To exploit the existing potential, require development, production, multiplication, processing, storage, marketing and use of new improved

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varieties and quality seeds. The importance of quality seed has been recognized since times immemorial and farming of crops was started to improved crop production. The foundation of production system across all farmers is access to quality seed. The use of quality seed is considered as essentialaspect for increasing yield. Quality seed widely supports for efficient utilization of inputs and growth resources. Modernization of agriculture laid out grounds in Ethiopia but will not be sustainable without consistentsupply of quality seeds. Quality seed is not only the basic input and initial to raising productivity but also enhances product quality. Thus, providing of required quality seed at right time and desired place is inevitable to feed ever increasing population and enabled ensured national food security.

Measuring the contribution of improved varieties and quality seeds for increasing final yield is vital to validate investment return on development of crop varieties and seed sector. But the process remains challenging as it is not easy to untangle the contribution of seeds from other agricultural inputs and management practices. Keeping other agricultural inputs and management practices constant, the usual method is to estimate the overall contribution of newly released crop varieties over farmers saved seeds of same varieties disseminated several years ago. The major assumptions are the farmer sourced seeds were under local management and exposed to natural and artificial contamination under local circumstance. Together with the depicted genetic and physical contamination, the quality of the seed is deteriorated overtime and affects quality and quantity of production. On the other hand the C1 seeds are produced under strict regulation and strong management that ensured utmost genetic and physical purity. The alternative hypothesis designed for seed quality research were seeds with C1 quality will produced higher yield with greater quality whereas farmer saved seeds produced lower yield with poor quality. The basis of null hypothesis was farmers' knowledge, skill and practice of seed production and maintenance is improved due to exposure and capacity building training to growers on quality seed production by ISSD and partners engaged in the area. Thus, farmers' capacity to keep genetic and physical purity of subsequent generation of seeds is improved. Therefore, the performance of farmers sourced and C1 seeds will be comparable in terms of yield and related components.

Research has been scanty that compares the yield and related variations where this study is one of a kind addressing the issues surrounding productivity potentials of different grades of seeds. As such, tailored seed value chain interventions are missing. Due to the lack of evidence base on the yield differences of seed classes, seed producers (SPCs, PSPs and individual farmers) are mandated to engage in C1 multiplication using basic seed. This might have limited their business cases and commercial niches. Lack of evidence is also associated with farmers' assumption that they don't see the difference between the different classes of seeds hence ultimately undermining the commercial gains of direct seed marketing. One of the challenges with DSM is that farmers generally lack participatory research evidence that strongly reveal the yield relevance of the different classes of seeds. The research will also help policy makers and practitioners to promote the importance of seed quality (at different levels) in agricultural productivity. While testing the yield differences of different seed classes new innovations and practices can emerge that can scaled out to farmers fields. The research can facilitate the potential for QDS registration for lower classes seeds of farmers like C2, C3, C4 and C5.

This research was designed to see the effect of quality seeds on final yield of the crop and to use the result to promote using of quality seeds for augmenting production and ensuing food security. This study was conducted to evaluate performance of different seed qualities (seed classes) of barley for yield and yield related components. As far as the knowledge of researchers was concerned, no research has been conducted so far with manifesting of seed quality effects on yield and yield components of food barley. Therefore, evaluation of the effect of seed quality, environment, varieties and their interaction effect plays essential role to improve yield and related traits of food barley.

Objectives of the Experiment:

- To illustrate performance of different seed qualities of barley for yield and yield related traits.
- To illustrate important of the resultto promote using quality improved seeds for augmenting production and ensuring food security.
- To investigate the environmental effect and variety by location interaction.

MATERIALS AND METHODS

Description of the Study Area: This study was conducted in four locations of southern, southeastern and eastern zone of Tigray during 2018 main cropping season at farmers' fields. Tigray is located border to Eritrea and north westsudden characterized by rugged mountains, valleys and plain lands. The region is structure into six administrative zones and 35 rural districts (locally called wereda-the second administrative level below the zone). Livelihood is mainly dependent on smallholder subsistence mixed crop/livestockproduction system and more than 80% of the population is directly dependent on this sector. The area receives highly mono-modal nature of rainfall that usually occurs between late June and early of September as well as bimodal natures in same pocket areas during short rain season that occurs from March to May.

Experimental Material and Field Trials: The treatments consists of three improved food barley varieties of *Felamit, Fetina* and *HB* with seed class of C1 and the same varieties with seed class of farm savedcollected from seed producing cooperatives and farmers owned saved respectively. The six treatments were laid outina randomized complete block design and replicated four times.The gross plot size was 1.2x2.5m (3 m^2) and the distance between plots and replications was 0.5m and 1cm, respectively. The treatments were assigned to each plot by random manner. The varieties were sown in rows of 20cm apart. Land preparation was done before onset of rains. Seeds were sown in rows by hand using recommended seeding rate of 100 kg/ha in 2018. Diammonium phosphate (DAP) fertilizer was applied at rate of 100 kgha^{-1} during sowing time and 100 kg ha^{-1} urea was applied in split at sowing and flowering stage. All the agronomic practices recommended for seed productionwere applied uniformly for all treatments.

Data Collection and Measurement: The entire plots were used for collecting and measuring data on phonological and growth parameters. Barleygrains were harvested from the whole plots to determine grain yield, 100-seed weight, shoot biomass yield, straw yield and harvest index. Individual plant parameters were determined from five randomly selected plants from the central parts of each plot.

Phenological Data: The following data were recorded.

Days to Heading: The number of days elapsed from the dates of seedling emergence up to the date when the tips of the panicles first emerged from the main shoot on 50% of the plants in a plot as determined by visual observation.

Days to Maturity: The number of days that elapsed from the date of sowing to the date when stems, leaves and floral bracts of 90% of the plants in a plot changed to light yellow color as determined by visual observation.

Growth and Yield and Yield Component: The following growth parameters of yield and yield components were recorded at maturity.

Plant Height: Height of the plant was measured in centimeter from the base of the main stem to the tip of the panicle of the main shoot and recorded as the average of 10 randomly selected plants.

Spike Length: Length of the spikes was measured in centimeter from the node where the first panicle branch starts to the tip of the panicle of the main shoot and recorded as the average of 5 randomly selected plants.

Number of Spikelet per Spike: The average number spikelet was counted on 5 randomly selected pre-tagged plants and the average was taken for analysis.

Number of Total Tillers: The total number of tillers was counted on randomly selected 5plants per plot at dough stage to determine total tillers per plant.

1000-Seeds Weight: The weight of counted 1000 seeds in gram was recorded at harvest in each respective plot using a sensitive balance.

Grain Yield: The weight of yield of was measured in gram after ten days of air-drying following harvest and converted into kg ha^{-1}.

Total Biomass: The weight of the total above ground biomass (Grain plus straw) of plants from the entire plots at harvest in kg was recorded in gram and converted into kg ha^{-1}.

Straw Yield: From the aboveground dry biomass, the grain yield was subtracted to get the straw yield on plot basis (g) and converted into kg ha^{-1}.

Harvest Index: The ratio of grain yield to total above ground (Shoot + grain) biomass was recorded from the entire plot.

Standard Germination Test: The germination test was done for all samples obtained from treatments. Four hundred pure seeds were replicated into four (with one hundred seeds each)were placed in germination box size of 18, 13 and 9 cm length, width and height respectively and sown in sterilized sand media. The germination media were incubated for seven days at a temperature of 20°C as specified by international seed testing agency [4]. The germination boxes were removed and the numbers of seeds germinated were counted.

$$\text{Germination \%} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} X100$$

Data Analysis: All the data collected were subjected to analysis of variance (ANOVA) using SAS, version 9.1.3, general Linear model (GLM) procedures [5]. Means were compared using the least significant difference test (LSD) at $p < 0.05$ significant level.

RESULTS AND DISCUSSION

Seed Germination Test: Seed is a living entity and one of its quality attributes is germination rate thatindicates the percentage of seeds emerging in the field. The experiment result indicated that the overall mean germination for *felamit, fetina* and HB1307 were 98.5, 99 and 98% respectively. The mean germination percentage for certified (C1) seeds of *felamit* was 99% whereas 98% for farmers saved (Figure 1). On the other hand, similar mean germination percentage was recorded among seeds of fetina and HB1307 varieties regardless of class differences. Even though, higher mean germination of C1 sourceswas recorded under seed classes of *felamit,* comparable mean germination percentage was obtained on rest of varieties. Therefore, the result indicated that the seed classes used did not affect the germination capacity and seed vigor in field establishment. The awareness raising program provided by integrated seed sector development (ISSD) and other stakeholders working in the area improved subsequent generations of quality seed production and handling by producers. Thus, the use of certified and farmers saved seeds did not affect significantly germination rate and final productivity. Producers can use quality declared seeds in areas where availability and access of certified seeds is problematic.

Crop Phenology: Seed quality and performance of three food barley varieties for varied phenological and yield and yield related traits are presented below consistently. The analysis of variance indicated that days to heading was highly significantly ($P \leq 0.001$) affected by the main effect of variety at Ayba but no variation was observed in other locations. Day to maturity was differed highly significantly ($P \leq 0.001$) at Ayba and significantly ($P \leq 0.05$) in other location by main effect of variety (Table 1). HB1307 took longer days both to heading and maturity and followed by Felamit whereas Fetina was earlier to maturity. Felamit and HB1307 were late matured varieties whereas Fetina was early matured. The mean longer days to maturity was recorded at Ayba and closely followed by varieties grown at Habes. Significant variation was not seen for phenological traits with usage of quality seed except days to maturity at Hagereselam.

Plant Height and Yield Components: Plant height is an essential growth character directly linked with the productive potential of plants in terms of fodder and grain yield. The height of the crop is believed to be positively correlated with yield of the crop. Significant variation at ($P \leq 0.05$) in plant height was observed in two locations (Mekhan and Habes) whereas no variation was detected in rest of the trial sites (Table 2). Statistically tallerplant height was recorded with both Felamit and Fetina at Habes and Mekhan whereas shortest was recorded with HB1307 in the same location. The varied in growing conditions and potential of the experimental sites showed variations in plant heights of the same variety. The shortest mean value of plant height was obtained at Hagereselam whereas the taller was recorded at Ayba. The applications of recommended inputs, equal amount of seed rates and agronomic management practices did not affect the aerial inter plant competition forspace and light energy. Thereby, the less stiff in aerial competition results statistically equivalent plant height.

Spike length is one of the major yield attributes of barley which is positively correlated with grain yield. Spike length measured at physiological maturity showed highly significant and significant difference ($P \leq 0.001$ and $P \leq 0.05$) due to the main effects of variety at Ayba and Hagereselam respectively (Table 2). The longer the spike length was obtained from Fetina both at Habes and Hagereselam and the second highest spike length was obtained from HB1307 in the same location but statistically on parwith spike lengthof Felamit at Habes. The shortest spike length was revealed with Felamit at Ayba. The longer mean value of spike length (7.77) was obtained at Habes whereas the second (6.96) was obtained at Ayba but the lowest (5.65) was recorded at Mekhan. Regardless of the significant variation in plant height among varieties, taller plants were recorded

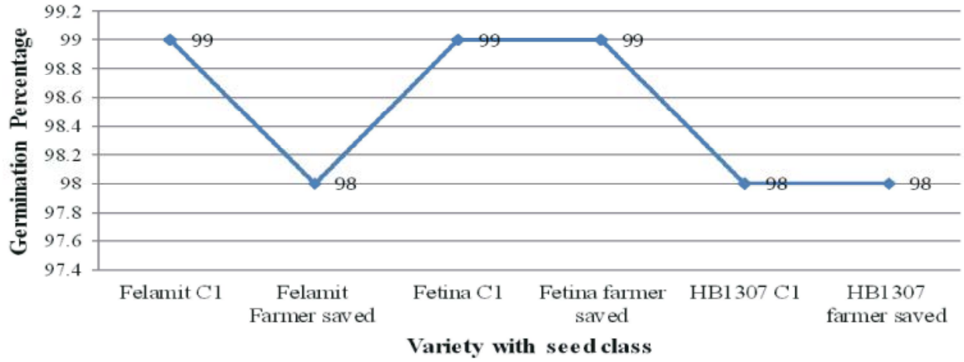

Fig. 1: Physiological quality (germination) food barley varieties from different sources in Tigray

Table 1: Mean value of day to heading and maturity of food barley varieties at four locations

Treatments	Mekhan	Ayba	Habes	Hagerselam
Days to heading				
HB1307	80.63[a]	72.750[a]	76.0[a]	75.13[a]
Felamit	80.0[a]	71.88[a]	74.38[a]	75.13[a]
Fetina	78.63[a]	65.13[b]	75.0[a]	74.14[a]
Mean	79.75	69.92	75.13	74.79
LSD (0.05)	2.73	1.64	2.99	3.40
Days to maturity				
HB1307	111.38[a]	120.13[a]	118.13[a]	107.50[a]
Felamit	107.75[b]	113.88[b]	114.13[b]	104.00[b]
Fetina	103.88[c]	109.63[c]	108.38[c]	100.38[c]
Mean	107.67	114.54	113.54	103.96
LSD (0.05)	3.28	3.32	2.29	3.043

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference.

Table 2: Mean value of yield components of food barley varieties grown 2018 main season at four locations in Tigray

Treatments	Mekhan	Ayba	Habes	Hagerselam
Plant height				
HB1307	91.11[b]	102.14[a]	89.59[b]	81.80[a]
Felamit	99.61[a]	104.37[a]	99.84[a]	86.58[a]
Fetina	98.95[a]	99.45[a]	99.77[a]	82.68[a]
Mean	96.56	101.98	96.39	83.68
LSD (0.05)	6.01	6.21	6.53	6.33
Spike length				
HB1307	5.59[a]	6.88[b]	7.75[b]	6.70[a]
Felamit	5.16[a]	6.33[c]	7.23[b]	6.83[a]
Fetina	6.19[a]	7.73[a]	8.35[a]	7.08[a]
Mean	5.65	6.96	7.77	6.87
LSD (0.05)	1.03	0.45	0.53	0.57
Total tiller per plant				
HB1307	2.18[a]	3.63[ab]	5.25[a]	4.10[c]
Felamit	2.63[a]	3.05[b]	4.63[b]	5.58[b]
Fetina	2.55[a]	4.50[a]	3.55[ab]	7.13[a]
Mean	2.45	3.73	4.48	5.60
LSD (0.05)	0.65	1.17	1.17	1.08
Number of kernels per spike				
HB1307	42.45ab	55.50[b]	59.10[b]	57.25[a]
Felamit	45.7a	61.35[a]	67.20[b]	42.60[b]
Fetina	34.18b	26.88[c]	26.63[c]	25.40[c]
Mean	40.78	47.91	50.98	41.75
LSD (0.05)	9.55	4.94	3.835	11.99

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference.

at Ayba and Mekhan but still shorter spike was obtained in these locations. It is natural that with the height of the plant increases, spike length is also increasing but this was not observed at Mekhan. Varieties grown both at Mekhan and Ayba were severely lodged at early heading stages because of the high amount of rainfall received. Thus, lodging affects translocation of photosynthetic products from sources to sink and hence limits elongation of spikes. The longer the spikes were recorded with shorter and non-lodged experimental plots and sites.

The number of total tillers per plant is the most important yield component because the final yield is mainly the function of panicle-bearing productive tillers per unit area. As the number of total tillers per plant increases, the straw and grain yield of crops also increases.The analysis of variance showed highly significant difference ($P \leq 0.001$) at Hagerselam and significant ($P \leq 0.05$) by the main effect of variety at Habes and Ayba (Table 2). The result indicated that maximum number of tillers was recorded from Fetina at Ayba and Hagerselam but statistically on par total tillers were recorded with the same variety at Habes and with HB1307 at Ayba. The lower number of tillers was recorded from Felamit variety in all locations but statically equivalent with tillers obtained from HB1307 at Ayba, from Felamit and Fetina at Habes and Felamit from Hagereselam. The maximum mean value of tillers was obtained from both Habes and Hagereselam whereas the shortest plant height was recorded in the same areas. This showed that under taller plants, there was a reduction in the overall growth and size of each plant and the number of total tillers formed will be become smaller. With increasing in height of plants, the photosynthetic products will be allotted more to shoot part to become effective in stiff aerial competition. But in shorter plants aerial competition is less and total tiller number and overall growth in size of plants will be increase due to increasing share of investment from photosynthesis products to root, stem and shoot parts. Thus, the observed severe lodging problem also affects tiller formation at Ayba and Mekhan.

Mean difference was observed among the barley varieties for number of spikelet per spike (Table 2). The maximum spikelet per spike was recorded with variety Felamit both at Mekhan and Ayba but was statistically comparable with spikelet number obtained from HB1307 variety at Mekhan. The second highest number of spikelet was recorded with HB1307 both at Ayba and Habes, Felamit at Habes and Hagerselam and Fetina variety at Mekhan but statistically similar result was revealed by the same variety at Mekhan whereas the lowest number of spikelet was recorded with Fetina variety in Ayba, Habes and Hagereselam. The lower numbers of spikelet per spike was recorded with Fetina variety at Ayba, Habes and Hagereselam experiment sites. Generally, the lower mean value of spikelet per spikes was recorded at Mekhan and the maximum was obtained at Habes.

Yield and Yield Related Traits of Barley: The statistical analysis revealed that grain yield was significantly ($P \leq 0.01$) affected by main effect of varieties at *Hagereselam* and *Ayba* but not affected by the main effect of variety at *Mekhan* and *Habes* areas (Table 3). The maximum yield recorded at *Ayba* was 5316.3 kgha^{-1} using HB1307 variety whereas, the yield obtained from *Felamit* and *Fetina* were statistically comparable. The higher statistically comparable grain yield 2731.8 and 2468.6 kgha^{-1} was recorded at *Hagereselam* from HB1307 and Felamit respectively. But the lowest yield at *Hagereselam* was recorded from *Fetina* variety whereas; the varieties did not reveal yield difference in the rest of growing areas.

Grain yield is the function of integrated effect of yield related traits which are influenced differently by growing conditions, management practices, genetic potential and seed quality. *Mekhan* and *Ayba* are high potential production areas and the growing season conditions were so good. Therefore, the performance of barley varieties was quiet better in such areas in the field and hence results comparable economic yields. On the other hand, the growing condition at *Habes* and *Hagereselam* were similar to other locations but the areas were different in terms of production potential. The potential difference in these areas brought yield variability due to varieties capacity to adapt and growing well in such fertility diminished soils. Even though, recommended management practices were applied, it is natural to see yield variability in such areas because of differences in environment and genetic potential of varieties. The farmers source seed though not inferior for grain yield due to buffering effect was inferior due to phenotypic variation for days to heading, number of kernels per spike, above ground shoot biomass and straw yield. This level of variation in seed is not acceptable as the non-uniformity of the crop produce is affected.

Table 3: Mean value of grain yield of food barley varieties affected at main effect of varieties at individual location level

Treatments	Mekhan	Ayba	Habes	Hagerselam
HB1307	4574.30^{ns}	5316.3^{a}	2698.90^{ns}	2731.80^{a}
Felamit	4457.90^{ns}	3439.5^{b}	2184.00^{ns}	2468.60a
Fetina	4243.10^{ns}	3397.4^{b}	2505.90^{ns}	1959.60^{b}
Mean	4425.12	4051.04	2462.94	2386.65
LSD (0.05)	1489.00	1441.10	730.46	507.08

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference.

The total shoot dry matter produced by a plant as the result of photosynthesis and nutrient uptake, minus that lost by respiration is called biological yield [6]. Plants have the ability to compensate for low populations by producing more tillers. The dry matter of plants per unit area of land usually increases asymptotically as density increases. The asymptote extends over a wide range of densities, due mainly to the large plasticity of individual plant size, which determines that mean plant dry weigh declines to exactly compensate for increase in density; that is, proportionate reduction in dry weight occur as densities increase above the normal sown density [7].

Mean difference was recorded among barley varieties grown across locations for biomass yield except at Hagereselam (Table 4). The maximum above ground shoot biomass yield was recorded by HB1307, *Felamit* and *Fetina* varieties at Mekhan, Ayba and Habes respectively but *Felamit* at Ayba was statistically on par. The second highest biomass yield was obtained with HB1307, *Fetina* and *Felamit* at all locations except Hagereselam and statistically comparable with *Felamit* at Ayba. The site mean value was 13430.56 kg ha^{-1}atMekha, 16527.78 kg ha^{-1} at Ayba, 9625.0 kg ha^{-1} at Habes and 9666.67 kg ha^{-1} at Hagereselam. Yield potential of Mekahn and Ayba were higher than other locations but Hagereselam was intermediate. Higher biomass yield obtained at Ayba and lower biomass yield obtained at Habes was attributed to high and low soil fertility potential of the study area respectively. Biomass yield is directly related with plants height, spike length, number of plants and grain yield per unit area. The longer plant, dense growth and higher yield were observed at Mekhan, Ayba, Habes and Hagereselam respectively as depicted in the result.

Table 4: Mean value for shoot biomass, grain yield, thousand seed weight, straw yield and harvest index at four sites

Treatments	Mekhan	Ayba	Habes	Hagerselam
Shoot biomass				
HB1307	14125[a]	15000[b]	8958[b]	9416.7[a]
Felamit	14292[a]	16417[ab]	8458[b]	9791.7[a]
Fetina	11875[b]	18167[a]	11458[a]	9791.7[a]
Mean	13430.56	16527.78	9625.0	9666.67
LSD (0.05)	2218.7	2786.9	2157.2	1225.5
Thousand Seed Weight				
HB1307	50.81[ab]	41.83[b]	53.51[b]	44.43[a]
Felamit	47.79[b]	33.96[c]	49.645[b]	50.29[a]
Fetina	53.085[a]	58.93[a]	65.71[a]	45.51[a]
Mean	50.56	44.90	56.29	46.74
LSD (0.05)	3.65	6.3926	8.21	9.9625
Straw yield				
HB1307	9550.7[a]	9683.7[b]	6259.4[b]	6684.9[b]
Felamit	9833.8[a]	12977.2[a]	6274.3[b]	7323.1[ab]
Fetina	7631.9[b]	14769.3[a]	8952.[a]	7832.1[a]
Mean	9005.43	12476.73	7162.07	7280.014
LSD (0.05)	1844	2128.9	2055.8	1045
Harvest index				
HB1307	0.32[a]	0.35[a]	0.30[a]	0.29[a]
Felamit	0.32[a]	0.21[b]	0.28[ab]	0.25[a]
Fetina	0.35[a]	0.19[b]	0.22[b]	0.21[b]
Mean	0.33	0.25	0.27	0.25
LSD (0.05)	0.09	0.07	0.07	0.04

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference.

The analysis of variance was highly significant at ($P \leq 0.001$) and significant at ($P \leq 0.05$) among the varieties for thousand seed weight grown at Ayba, Mekhan and Habes respectively but no statistical different were observed among varieties grown at Hagereselam (Table 4). The higher thousand seed weight was recorded across all locations except ayba and was statistical on par with thousand seed weight observed from HB1307 at Mekhan. The second highest thousand seed weight was recorded from Felamit and HB1307 at Mekhan, Ayba and Habes and was statistical on par with HB1307 at Mekhan whereas the lower was recorded from Felamit at Ayba. On the other hand, mean different was observed for straw yield per hectare across all location and the maximum straw yield was recorded from all varieties at Ayba followed by mekhan. Similarly, the lowest straw yield was recorded still across all location among varieties.

The ANOVA of harvest index revealed significantly ($P \leq 0.05$) effect due to the main effect of varieties across all location except Mekhan (Table 4). The maximum harvest index was recorded from HB1307 at Ayba, Habes and Hagereselam and Felamit at Hagereselam and was statistically on par with Felamit at Habes. In general, C1 seed was significantly superior to C3 for days to heading and numbers of kernels per spike whereas, even though not showed statistically variation, farmer source seed was superior to C1 for above ground shoot biomass and straw yield. The C1 seed showed 1.7% superiority for days to heading, 7.9% for number of kernels per spike but showed 9.5% inferiority for above ground shot biomass yield and 6.8% for straw yield.

Combined Analysis Result: Days to heading and maturity were both highly significantly different ($P \leq 0.001$) on main effect of seed quality of varieties and environment. The statistical analysis indicated that days to heading was statistically differ at ($P \leq 0.05$) level of significant due to the main effect of seed quality. The recorded day to heading was ranged from 73.22 to 76.13 with mean value of 74.89 days whereas; days to maturity were ranged from 105.56 to 114.28 with mean value of 109.93 days. Even though, it was not statistically different, longer days to heading (76.13) were recorded with HB1307 while the shorter was 73.22 days with *Fetina* variety (Table 5). Similarly, the longer day to maturity was recorded (114.28) days with *HB1307* whereas, the shortest (105.56) days was recorded with *Fetina*. *Fetina* was the earliest variety to heading and maturity whereas HB1307 was the late variety both to heading and maturity. *Felamit* was medium to heading and maturity. The variation for phenological traits was high among the test varieties to days to maturity but statistically comparable for days to heading. The longer number of days to heading was obtained from using of C1 but days to maturity were statistically comparable to quality seed. The variation in phenology was more apparent on C1 compared to farmer saved seeds. Tigray is drought prone area and frequent droughts have been occurred. The seasonal rainfall variability is significantly high and affects crops at different growth stages. Varieties with earlier heading and maturity date have the advantage to escape terminal moisture stresses and drought and required to cope with the seasonal rainfall variability in Tigray.

Height, length, number of tillers and spikelet are claimed to be positively correlated with biological and economic yield of crops. The analysis of variance revealed that highly significant variation ($P \leq 0.001$) on main effect of variety for spike length and number of spikelet per spike of the varieties. The main effect of variety on plant height and total tillers per plant were significantly different at ($P \leq 0.05$) whereas, main effect of environment was highly significantly different ($P \leq 0.001$)

Table 5: Mean value of phenological and yield components of food barley varieties combined across locations in Tigray

Treatment	Days to heading	Days to maturity	Plant height	Spike length	Total tillers per plant	Number of kernels per spike
	Main effect of variety on phenological, yield and yield components					
HB1307	76.13^{a}	114.28^{a}	91.16^{b}	6.73^{b}	3.79^{a}	53.575^{a}
Fetina	73.22^{a}	105.56^{c}	95.21^{ab}	7.33^{a}	4.43^{a}	28.269^{b}
Felamit	75.34^{a}	109.94^{b}	97.59^{a}	6.38^{b}	3.97^{a}	54.21^{a}
Mean	74.89	109.93	94.66	6.82	4.06	45.35
LSD (0.05)	3.22	1.63	5.22	0.44	1.78	14.647
	Main effect of quality seed on phenological, yield and yield components					
C1	75.54^{a}	110.35^{a}	94.44^{a}	6.804^{a}	4.13^{a}	47.41^{a}
Farmer saved	74.25^{b}	109.50^{a}	94.878^{a}	6.83^{a}	3.99^{a}	43.29^{a}
Mean	74.89	109.9271	94.66	6.82	4.06	45.35
LSD (0.05)	1.19	2.86	4.73	0.14	0.66	10.49

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference.

for all traits of plant height, spike length, total tillers per plant and number of spikelet per spikes but statistically equivalent to quality seeds (Table 5). The analysis of variance on main effect of quality seed for number of spikelet per spike was significantly different at (P ≤0.05) level of significant. The shortest (91.16cm) of plant height was obtained from variety HB1307 and statistically comparable with *Fetina* (95.21cm) whereas the tallest (97.59) was recorded from *Felamit* but statistically comparable with *Fetina*. During the experiment, high rainfall was received and most varieties in the plot were lodged and affects data measurement mainly plant height. Spike length is the major yield attributor of barley and positively correlated with final yield. The shorter spike length (6.73 and 6.38cm) was obtained from both HB1307 and *Felamit* varieties whereas the taller (7.33) was obtained from *Fetina* but total tillers per plant were statistically comparable. The mean value revealed that the larger number of kernels per spike (53.58 and 54.21) was recorded with HB1307 and *Felamit* respectively but seed quality was not affect kernels per spike.

Analysis of variance indicated that seed quality were not significantly affected (P ≤0.05) by main effect of location (Table 6). Even though, the main effect of seed quality did not statistically affect the final yield, yield variation was recorded in varied seed qualities. The higher yield reduction was recorded using of C1 seed at Ayba by 15.57% compared to farm savedseeds and the second highest yield reduction was recoded still with C1 at Mekhan by 10.72% relative to farm saved. Similarly, the lowest yield reduction using C1 seed was recorded at Habes by 13.86% relative to farm saved seeds. The sole yield increment (7.80%) was seen using C1 seed at Hagereselam. The even distribution of seasonal rainfall and health growing condition of this year enabled growing crops to perform comparable at fields and effect of seed quality on yield was not statistically visible.

Table 6: Mean value of main effect of seed quality and environment on yield of food barley varieties across locations

	Yield kg in ha		
ENV	C1	Farm saved	Yield advantage %
Mekhan	4174.4^{a}	4675.8^{a}	-10.72
Ayba	3709.0^{a}	4393.0^{a}	-15.57
Habes	2279.6^{a}	2646.3a	-13.86
Hagereselam	2476.2^{a}	2297.1^{a}	7.80

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference

Table 7: Mean value of main effect of seed qualityon yield of food barley varieties

	Seed class		
Site	C1	Farm saved	Yield advantage
Felamit	3049.96a	3224.99a	-5.43
Fetina	3067.07a	2985.91a	2.72
HB1307	3362.43a	4298.27a	-21.77

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference

The result ascertained that performance of varieties is depends on favorable growing conditions and under conducive growing conditions, yield variability would not be significantly large among growing varieties. It is convincing that the effect of conducive environmental conditions on growth and equivalent performance of different varieties under varied locations.

No variation was detected statistically on barley yield due to main effect of seed quality (Table 7). Even though, the yield variations by seed quality was not statistically significant, there was little yield decrement in using of different seed qualities. The higher yield decrement (21.77%) was recorded with HB using C1compared to farm saved seeds whereas the second higher reduction (5.43%) was obtained using C1 seed of *Felamit* variety.

Table 8: Mean value of yield and yield components of food barley varieties combined across locations in Tigray

Treatment	Shoot Biomass	Grain Yield	Thousand Seed Weight	Straw Yield	Harvest Index
Main of effect of variety on yield					
HB1307	11875[a]	3830.3[a]	47.643[a]	8045[a]	0.32[a]
Fetina	12823[a]	3026.5[a]	55.808[a]	9796[a]	0.24[a]
Felamit	12240[a]	3137.5[a]	45.420[a]	9102[a]	0.26[a]
Mean	12312.50	3331.44	49.62	8981.06	0.27
LSD (0.05)	2457.8	831.03	11.41	2773.9	0.08
Main of effect of quality seed on yield					
C1	11847.2a	3159.8[a]	50.38[a]	8687.4[a]	0.27[a]
Farmers Saved	12777.8a	3503.1[a]	48.87[a]	9274.7[a]	0.28[a]
Mean	12312.50	3331.44	49.62	8981.06	0.27
LSD (0.05)	1016	591.54	4.47	1270.6	0.06

Means followed by the same letter with in a column in the same treatment category are not significantly different at 5% level of significance. NS= non-significant; CV = Coefficient of variation; LSD = Least significant difference

On the other hand, the only yield increment (2.72%) was depicted using C1 Fetina variety. The use of different seed qualities did not brought significant yield changes under current experimental conditions. This might be due to the quality of farmers sources seed is either comparable or better than C1 seeds received from seed producing cooperatives. Similarly, the favorable growing condition of this cropping season has contributed for the equivalent performance of growing varieties across locations regardless of seed quality. On the other hand, the result proved that the farmers saved seeds were comparable in quality with C1 seeds produced by seed cooperatives. ISSD has been working just for a decade in changing farmers' attitude in seed production, processing and handling. This result ascertained that how much famers are informed and aware about productionof quality seeds and handling without deteriorating genetic and physical purity.

Mean value of shoot biomass, grain yield, thousand seed weight, straw yield and harvest index of each variety and seed quality are depicted in (Table 8). The analysis of variance for all yield traits were not significantly affect by the main effect of variety and seed quality. Growing environment has an impact on growth, development and fully expression of genetic potential of growing crops for agronomic yield. Crop environment has exerts a great influence on growth and final yield and is the function of water, nutrient, climate and soil environment. The favorable growing condition during the experiment enabled to grow and provide comparable yield of varieties regardless of seed quality used. Effect of growing condition was more prevailed than seed quality used and varietal difference on performance to yield and related traits.

CONCLUSION

The objective of this study was to illustrate the performance of different seed qualities of barley varieties for yield and related traits. The presence of significant variations among the tested varieties for most plant characters indicated that there is variability among the tested varieties. Mean different of days to heading and maturity were observed due to the main effect of variety. The HB1307 and Fetina were the varieties taken long and short days both to heading and maturity in study locations. Significant variation in plant height and spike length was observed among varieties in the study locations and the taller was recorded with both Felamit and Fetina and the shortest with HB1307 whereas the taller spike length was observed in Fetina and Felamit. Mean value of total tillers and spikelet per spike was showed significant differencedue to main effect of variety and maximum was recorded with Fetina and HB1307 for tillers but maximum spikelet was recorded with Felamit. Significant difference in mean thousand seed weight, economic and biomass yield was observed and the maximum economic yield was recorded with HB1307 at Ayba and statistical on par biomass yield was recorded among varieties across study locations. The larger mean thousand seed weight was recorded across all locations except at Hagereselam. Mean significant different was observed with straw yield and harvest index and statistical on par straw yield was observed among varieties in all locations whereas the maximum harvest index was recordedfrom HB1307 variety. No variation was detected statistically on barley yield due to main effect of seed quality. This study indicated that prevailed of favorable growing conditions during the experimental season has contributed for the equivalent performance of growing varieties across locations regardless of seed quality. The result indicated that additional minimum improvement should be essential for barley yield and related agronomic traits. Therefore, attention should be given for further exploitation of genetic variability for varietal improvement to enhance better yield and ensured food security.

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