Kofahi, 2010). After artificial aging seeds were left air drying at ambient conditions (24±2°C) until seed moisture dropped to an acceptable percentage, then, stored at 5°C until used for field studies (Samarah and Al-Kofahi, 2010).

Treatments and experimental design

The experiment consisted of 18 factorial combinations of treatments. The treatments were laid out in a randomized complete block design, in two factorial arrangements with three replications at the experimental field of Holeta and Kulumsa agricultural research centers. The factors are five deterioration/aging days 0 (control/un-aged), 2, 4, 6, 8, and 10 days and three seed rates (75, 100, and 125 kg/ha). The gross experimental area at one location was 28.4 m×10.5 m=298.2 m^2, and spacing of 1.5 m between blocks and 0.4 m between the plots was used. The gross size of each plot was 1.2 m×2.5 m=3 m^2 consisting of six rows with the net plot size of 0.8 m^2×2.10 m^2=1.68 m^2 having a spacing between rows 0.2 m and all agronomic practices were applied as per the recommendations. To avoid the border effect, only four middle rows were harvested after physiological maturity from the net plot area and threshed manually.

Data collection

Crop phenology

Days to heading (DH)

The number of days taken from the date of sowing until the ear or panicles was fully visible on all plants from each plot by visual observation.

Days to maturity (DM)

It was determined as the number of days from sowing to the date when the peduncle turned yellow in straw color. It was recorded when grains were difficult to break with a thumbnail.

Grain filling periods (GFP)

It was the day's gap between DH and DM.

Growth parameters

Plant height (PH)

Was measured from the soil surface to the tip of the spike of ten randomly selected plants from the net plot area at physiological maturity and expressed in centimeters.

Spike length (SL)

It was measured on ten randomly selected plants from the bottom of the spike to the tip of the spike and the average was expressed in centimeters.

The number of seeds per spike (NSPS)

The NSPS for each plot was counted from the ten tagged plants and the average was expressed in centimeters.

Yield and yield-related parameters

MCs

MC was determined using the indirect moisture testing meter HE light following international rules for seed testing in the seed technology laboratory of Holetta Agricultural Research Center.

Thousand kernels weight (TKW)

It was determined based on four samples of 1000 kernel weight taken from the grain yield (GYLD) of each net plot using an electronic seed counter and weighed with sensitive balance and finally, the mean was computed.

Above-ground dry biomass (AGDBM)

Was determined from plants harvested from the net plot area after sun drying to a constant weight and converted to ton per hectare.

Hectoliter weight (HLW)

It was flour density produced in hectoliter of the seed and it was determined using a HLW analyzer.

Table 1: Treatment combination in detail

Treatments number	Treatments combination
T1	Control/Un-deteriorated *IBON 174/03* variety and was planted with a seed rate of 75 kg/ha
T2	Control/Un-deteriorated *IBON 174/03* variety and was planted with a seed rate of 100 kg/ha
T3	Control/Un-deteriorated *IBON 174/03* variety and was planted with a seed rate of 125 kg/ha
T4	*IBON 174/03* variety deteriorated for 2 days and was planted with a seed rate of 75 kg/ha
T5	*IBON 174/03* variety deteriorated for 2 days and was planted with a seed rate of 100 kg/ha
T6	*IBON 174/03* variety deteriorated for 2 days and was planted with a seed rate of 125 kg/ha
T7	*IBON 174/03* variety deteriorated for 4 days and was planted with a seed rate of 75 kg/ha
T8	*IBON 174/03* variety deteriorated for 4 days and was planted with a seed rate of 100 kg/ha
T9	*IBON 174/03* variety deteriorated for 4 days and was planted with a seed rate of 125 kg/ha
T10	*IBON 174/03* variety deteriorated for 6 days and was planted with a seed rate of 75 kg/ha
T11	*IBON 174/03* variety deteriorated for 6 days and was planted with a seed rate of 100 kg/ha
T12	*IBON 174/03* variety deteriorated for 6 days and was planted with a seed rate of 125 kg/ha
T13	*IBON 174/03* variety deteriorated for 8 days and was planted with a seed rate of 75 kg/ha
T14	*IBON 174/03* variety deteriorated for 8 days and was planted with a seed rate of 100 kg/ha
T15	*IBON 174/03* variety deteriorated for 8 days and was planted with a seed rate of 125 kg/ha
T16	*IBON 174/03* variety deteriorated for 10 days and was planted with a seed rate of 75 kg/ha
T17	*IBON 174/03* variety deteriorated for 10 days and was planted with a seed rate of 100 kg/ha
T18	*IBON 174/03* variety deteriorated for 10 days and was planted with a seed rate of 125 kg/ha

GYLD

It was taken by harvesting and threshing the seed yield from the net plot area. The grain weight of each plot was recorded in kg/plot and converted to ton per hectare. The yield was adjusted to 12.5% MC.

Data analysis

All the data collected were analyzed with the analysis of variance (ANOVA) procedure using the statistical software package SAS version 9.3. The mean comparisons among treatments were done using Tukey's Standardize Range (HSD) test at a 5% level of significance.

RESULTS AND DISCUSSION

Growth, yield, and yield-related parameters of malt barley variety

The combined ANOVA for years across locations showed a highly significant difference ($p<0.01$) for all evaluated crop phenology, growth, yield, and yield-related parameters of the malt barley variety (Table 2). The main effect of deterioration/aging days showed a highly significant ($p<0.01$) difference in SL, above-ground biomass, and GYLD. On the other hand, the seed rate showed a significant ($p<0.05$) difference for thousand kernel weight (TKW) and a highly significant ($p<0.01$) difference for above-ground biomass and GYLD (Table 3). According to the ANOVA result interaction effect of deterioration days and seed, the rate was only significant ($p<0.05$) for TKWs whereas, it was non-significant for the rest of the evaluated crop phenology, growth, yields, and yield-related parameters of malt barley (Table 2).

SL

A SL was affected by deterioration days and as deterioration days progressed, the mean value for SL was significantly reduced. Un-aged

Table 2: ANOVA for crop phenology, growth, yield, and yield-related parameters of malt barley variety

Source of variation	DF	DH	PH (cm)	SL (cm)	NSPS	DM	GFP	MC (%)	TKW (g)	AGDB (t/ha)	GYLD (t/ha)	HLW
Year (Y)	1	192.63**	268.16**	20.92**	5.21**	192.01**	138.33**	1614.11**	390.67**	117.02**	79.53**	696.87**
Location (L)	1	174.16**	67.41**	53.05**	45.33**	182.29**	159.52**	13.05**	147.07**	76.78**	23.55**	82.12**
Replication (R)	2	0.01^{ns}	0.18^{ns}	6.82**	0.19^{ns}	0.14^{ns}	2.74^{ns}	0.39^{ns}	0.46^{ns}	0.01^{ns}	0.05^{ns}	0.58^{ns}
Deterioration days (DD)	5	0.01^{ns}	0.44^{ns}	18.76**	0.46^{ns}	0.00^{ns}	0.05^{ns}	0.06^{ns}	1.11^{ns}	6.58**	6.86**	0.50^{ns}
Seed rate (SR)	2	0.03^{ns}	0.06^{ns}	2.88^{ns}	4.43^{ns}	0.01^{ns}	0.11^{ns}	0.78^{ns}	3.36*	16.41**	11.19**	1.06^{ns}
DD*SR	10	0.00^{ns}	0.70^{ns}	0.95^{ns}	1.04^{ns}	0.01^{ns}	0.19^{ns}	0.69^{ns}	2.08*	0.99^{ns}	1.76^{ns}	0.52^{ns}
Error	194	17.47	16.44	9.36	3.45	17.84	14.55	77.94	27.23	12.83	8.45	37.62
CV		17.88	8.03	11.62	9.57	12.33	6.27	2.64	6.61	28.26	24.36	3.28
Grand mean		84.76	78.05	7.07	25.18	152.25	67.49	11.57	50	9.53	4.58	61.01

ns, * and ** insignificant, significant at $P<0.05$ and $P<0.01$, respectively. CV%: Coefficient of percent variation. DF: Degree of freedom, DH: Days to heading, PH: Plant height, SL: Spike length, NSPS: Number of seed per spike, DM: Days to maturity, GFP: Grain filling periods, MC: Moisture content, TKW: Thousand kernel weight, AGDB: Above ground dry biomass, GYLD: Grain yield, HLW: Hector litter weight, DD*SR=Deterioration*seed rate

Table 3: Main effect of deterioration day and seed rate on crop growth, yield, and yield-related parameters of barley variety

Deterioration day (in days) and Seed rate in (Kg/ha)	Mean value for crop growth, yield, and yield-related parameters				
	SL (cm)	NSPS	TKW (g)	AGDB (ton/ha)	GYLD (ton/ha)
Deterioration days (in days)					
0 (Control)	7.97^{A}	25.55	51.02	11.51^{A}	5.39^{A}
2	7.40^{B}	25.28	49.95	10.14^{AB}	4.88^{AB}
4	7.26^{B}	25.03	49.46	9.40^{B}	4.37^{BC}
6	6.51^{BC}	25.33	49.81	9.10^{B}	4.54^{BC}
8	6.88^{B}	25.12	50.26	8.66^{B}	4.05^{C}
10	6.51^{C}	24.75	49.50	8.36^{B}	4.23^{BC}
Mean	7.07	25.18	50.00	9.53	4.58
HSD (0.05)	0.56*	1.63^{NS}	2.24^{NS}	1.83**	0.76**
Seed rate (kg/ha)					
75	7.25	25.82^{A}	50.72^{A}	8.09^{B}	4.14^{B}
100	7.03	25.06^{AB}	49.30^{B}	9.93^{A}	4.58^{A}
125	6.92	24.65^{B}	49.98^{AB}	10.56^{A}	5.01^{A}
Mean	7.07	25.18	50.00	9.53	4.58
HSD (0.05)	0.32^{NS}	0.95*	1.30*	1.06**	0.44**
CV (%)	8.26	9.46	6.51	23.41	20.87

ns, * and ** insignificant, significant at $p<0.05$ and $p<0.01$, respectively. CV%: Coefficient of percent variation. This means that the same column followed by similar letters is not significantly different from each other at a 5% level of probability. SL: Spike length, NSPS: Number of seeds per spike, TKW: Thousand kernel weight, AGDB: Above-ground dry biomass, GYLD: Grain yield per hectare

or the control treatment recorded the highest SL (7.97 cm) whereas, barley variety aged for 2, 4, 6, and 8 days recorded (7.40 cm, 7.26 cm, 6.51 cm, and 6.88 cm SL), respectively, which was statically similar results and the lowest (6.51 cm) SL was recorded for barley seed deteriorated for 10 days (Table 3). The present study was in agreement with the result of (Mosanaei *et al*., 2017) who reported that the highest SL was observed in the non-deteriorated treatment in wheat seed in 2 years experiments (7.43 and 7.67 cm) and deterioration of 15 h in the 2nd-year experiment (7.36 cm) whereas, the lowest SL was obtained at the highest level of deterioration 45 h with a mean of 6.39 cm.

NSPS

According to the ANOVA results, the main effect of deterioration days was non-significant whereas, the seed rate per hectare was significant for the NSPS. The highest (25.82 and 25.06) NSPS was recorded for barley seed sown by seed rate of 75 kg/ha and 100 kg/ha, respectively. The result obtained from this study was in line with Senait Bekele *et al*., 2020, who reported that a maximum number of kernels per spike (30.61) was obtained from a 100 kg/ha seed rate, and a minimum number of kernels per spike (23.86 g) was recorded from the seed rate of 175 kg/ha and they concluded that as seed rate increased from 100 to 175 kg/ha, the number of kernels per spike was decreased by 28.20%. The result obtained from this study was also in line with (Hussanein, 2001) who reported that the higher grain number obtained in the lowest seeding rate can be attributed to more light penetration through the plant canopy. The decrease in the number of grains per spike by increasing sowing rates may be due to excessive densities (Workineh *et al*., 2015) Furthermore, increasing seeding rates from 100 to 150 kg/ha decreased the number of grains per spike from 32.02 to 29.60 (Worku Awdie, 2008). However, these findings were in line with Mehrvar and Asadi, 2006, who reported that by increasing the seeding rate, the number of grains per spike was reduced. The present study was also in agreement with the finding of Mosanaei *et al*., 2017, who used plant density at two levels (350 and 420 plants/m^2) and found a significant effect on the number of kernels per spike for the wheat crop. Mosanaei *et al*., 2017, finding reported that among plant densities except for the density of 420 plants/m^2 in the 1st-year experiment that was the lowest mean of this trait, other treatments had the highest average NSPS, i.e., as plant population increased the number of seed per spike decrease.

TKW

According to the present study, as the seed rate per hectare increased, the weight of a thousand seeds was reduced. The highest (50.72 and 49.98 g) TKWs were recorded for barley seed sown by seed rate of 75 kg/ha and 125 kg/ha, respectively (Table 3). According to Senait Bekele *et al*., 2020, the probable reason for the reduction of TKW for seed harvested from higher seed rate per hectare (100 and 125 kg/ha) might be due to high density caused by increasing number of spikes, and as a result of competition would increase and little photosynthesis would be available to grain filling and finally, the thousand-grain weight would reduce due to increasing number of spikes. Therefore, insufficient photosynthesis during the grain filling stage in thick density and also low vigor of the seed may be the possible reason for to decrease in TKWs. This finding was in agreement with the study of Senait Bekele *et al*., 2020, who reported that the highest TKW (43.96 g) was recorded for seeds sown at the seeding rate of 100 kg/ha whereas, the lowest TKW (35.59 g) was recorded at the seeding rate of 175 kg/ha and concluded that generally when the seeding rate increased from 100 to 175 kg/ha resulted in decreased TKW by 23.51%. This result was also in line with O'Donovan *et al*., 2011, who indicated that the kernel weight, diameter, and seed plumpness were lower at higher seeding rates. Similarly, (Wade *et al*., 2003) also found heavier kernel weights using low seeding rates. Similarly, Iqbal *et al*., 2010, concluded that lower seeding rates (125 kg/ha) produced significantly heavier grains (40.74 g) than higher seeding rates (200 kg/ha) that produced lighter (37.83 g) grains. McKenzie *et al*., 2005, reported that kernel weight declines with increasing seeding rate, which in turn reduces malt acceptability. The reduction in the weight of 1000 seeds in high densities may be due to the superiority of vegetative organs in competing with reproductive organs (Modarresi *et al*., 2002).

According to the ANOVA result interaction effect of deterioration days and seed, the rate was also significant (p<0.05) for TKWs of malt barley (Table 2). The highest TKW (52.88 g) was recorded for the un-aged *IBON* 174/03 variety sown with a seed rate of 125 kg/ha followed by un-aged *IBON* 174/03 variety and sown with a seed rate of 75 kg/ha (51.48 g) and aged seed for 8 days and sown with seed rate of 125 kg/ha (51.59 g), whereas the lowest TKW (48.29 g, 48.24 g, and 48.22 g) were recorded for *IBON* 174/03 variety aged for 2 days sown with seed rate of 125 kg/ha, aged for 4 days and sown with seed rate of 125 kg/ha and aged for 6 days and sown with seed rate of 100 kg/ha. The other treatment combination recorded an intermediate result with an overall mean value of 50 g thousand kernel seed weight. The present study was in line with the finding of Mosanaei *et al*., 2017, who reported that the highest mean of thousand seed weight was obtained for un-deteriorated wheat in the 1st and the 2nd-year studies (37.54 and 37.40 g), and the lowest mean of this trait was achieved in 45 h of seed deteriorating at the 1st year (33.29 g).

AGDBM and GYLD per hectare

The ANOVA showed that AGDBM and GYLD per hectare were significantly affected by aging days and seed rate. As deterioration day increased, the mean value for AGDBM and GYLD per hectare were significantly reduced. The highest AGDBM (11.51 and 10.14 ton/ha) and the highest GYLD per hectare (5.39 and 4.88 ton/ha) were recorded for the un-deteriorated/control and barley variety deteriorated for 2 days, respectively. Barley seed deteriorated for 4, 6, 8, and 10 days recorded statically similar results and it was the lower value as compared to un-deteriorated and barley variety deteriorated for 2 days (Table 3). In general, as deterioration day progressed from 2 to 10 days, AGDBM reduced by 13.5–37.68% as compared to un-aged/control treatment. This study was in agreement with the finding of Mosanaei *et al*., 2017, who reported that the highest average AGDBM (6438.6 kg/ha) in the 1st-year experiment was recorded for un-deteriorated/control treatment, and the lowest was recorded for seed deteriorated for 45 h (4931.40 kg/ha). Similarly, the highest average mean of AGDBM was recorded for un-deteriorated treatment (8931.7 kg/ha), and the lowest was recorded for seed deteriorated for 45 h (4531.4 kg/ha). For GYLD per hectare, the present study was also aligned with the finding of (Mosanaei *et al*., 2017) who reported among the levels of deterioration, the highest seed yield was achieved in the non-deteriorating in the 2nd year (4492.5 kg/ha), and the lowest average in 45 h of deterioration level was found in the 1st year (277.5 kg/ha). Seed deterioration caused a significant reduction in yield and the yield components of wheat seed, so the highest level of seed deterioration in the 1st and the 2nd years decreased 34.11% and 22.63% of the GYLD compared to the control treatment (Mosanaei *et al*., 2017). According to Mosanaei *et al*., 2017, plant growth seems to be affected by the negative effects of seed deterioration, which has led to a decrease in its biological yield. The seed deterioration with its effect on seed quality caused a decrease in emergence, seedling growth, and biomass, and ultimately reduced biological yield, and reduced biological yield caused reduced seed yield. The results of the experiment reported by Hampton, 2020, that showed a reduction in seed yield of barley due to the deterioration of the seeds are in agreement with the results of the present study. Although Ghassemi-Golezani *et al*., 2011, reported that the GYLD of maize plants aged for 9 and 12 days recorded reduced GYLD by 26.03% and 14.87%, respectively, as compared to the un-aged maize seed. Ghassemi-Golezani *et al*., 2010, also reported that biological and GYLDs per unit area significantly decreased with increasing seed aging.

Concerning the seed rate per hectare, barley seed sown by seed rate of 100 kg/ha and 125 kg/ha recorded the highest value of AGDBM and GYLD in ton per hectare and barley seed sown by seed rate of 75 kg/ha recorded lower value for both AGDBM and GYLD per hectare (Table 3). According to the present study seed, the rate increased from 75 to 125 kg/ha AGDBM and GYLD per hectare increased by 30.53% and 21.01%. This might be due to high plant density having a maximum number of spikes per plant that finally increased both AGDBM and GYLD per hectare. This shows that AGDBM and GYLD per hectare have a positive relationship with seed rate, i.e. as seed rate per hectare increased both above-ground biomass and GYLD increased. The present study is in agreement with the findings of Adinew, 2019; Ali *et al*., 2004; and El-Hebbasha, 2001, and Ali *et al*., 2004, were reported the maximum biological yield and GYLD per hectare at a higher seed rate than a lower seed rate. Moreover, Gafaar, 2007, reported that the highest value of biological yield was obtained with an increasing seed rate of up to 400 grains m^2 in wheat crops. This study was also in line with the study of Mosanaei *et al*., 2017, who reported that the highest biological yield was obtained in plant density of 420 plants/m^2 in the

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Table 4: The overall mean value for the effect of deterioration days and seed rates on crop phenology, growth, yields, and yield-related parameters of malt is barley

Variety	DD	SR	DH	PH (cm)	SL (cm)	NSPS	DM	GFP	MC (%)	TKW (g)	AGDB (t/ha)	GYLD (t/ha)	HLW
IBON/174/03	0	75	85.33	78.70	8.56^{A}	26.31	152.67	67.33	11.53	51.48^{AB}	9.81^{B-E}	4.64^{A-F}	61.40
IBON/174/03	0	100	84.92	79.40	7.56^{BC}	25.44	151.75	66.83	11.53	48.69^{BC}	11.45^{AB}	5.68^{AB}	60.28
IBON/174/03	0	125	85.17	75.27	7.79^{AB}	24.90	152.75	67.58	11.67	52.88^{A}	13.27^{A}	5.84^{A}	60.37
IBON/174/03	2	75	85.33	79.82	7.48^{BC}	26.45	152.83	67.50	11.65	50.85^{A-C}	9.05^{B-E}	4.7^{A-F}	61.28
IBON/174/03	2	100	84.42	79.71	7.57^{BC}	25.58	152.00	67.58	11.56	50.70 $^{A-C}$	10.85^{A-C}	5.12^{A-D}	61.42
IBON/174/03	2	125	84.25	77.41	7.16^{BC}	23.82	152.25	68.00	11.47	48.29^{C}	10.52^{A-C}	4.81^{A-F}	60.44
IBON/174/03	4	75	85.42	75.83	7.53^{BC}	26.08	152.25	66.83	11.60	50.13^{A-C}	8.50^{B-E}	4.34^{B-F}	60.87
IBON/174/03	4	100	84.25	77.58	7.23^{B-D}	24.95	152.58	68.33	11.53	50.02 $^{A-C}$	9.14^{B-E}	4.02^{C-F}	61.17
IBON/174/03	4	125	84.42	79.02	7.02^{C-E}	24.05	151.83	67.42	11.58	48.24^{C}	10.57^{A-C}	4.77^{A-F}	61.04
IBON/174/03	6	75	85.00	77.86	6.93^{C-E}	25.65	153.00	68.00	11.57	51.07 $^{A-C}$	7.02^{DE}	3.57^{EF}	61.68
IBON/174/03	6	100	84.25	78.65	6.76^{C-E}	25.65	151.42	67.17	11.58	48.22^{C}	10.14^{A-D}	4.80^{A-F}	60.93
IBON/174/03	6	125	84.75	79.61	6.94^{C-E}	24.68	152.42	67.67	11.59	50.16^{A-C}	10.13^{A-D}	5.24^{A-C}	61.44
IBON/174/03	8	75	85.00	78.35	6.57^{DE}	25.77	152.17	67.17	11.69	50.16^{BC}	7.29^{DE}	3.73^{EF}	61.43
IBON/174/03	8	100	84.50	76.41	6.55^{DE}	23.97	152.67	68.17	11.57	49.03^{BC}	9.98^{B-E}	4.40^{B-F}	61.51
IBON/174/03	8	125	84.92	76.90	6.43^{DE}	25.62	151.83	66.92	11.48	51.59^{AB}	8.71^{B-E}	4.57^{A-F}	60.47
IBON/174/03	10	75	84.67	77.80	6.42^{DE}	24.68	151.75	67.08	11.66	50.66^{A-C}	6.86^{E}	3.82^{D-F}	60.66
IBON/174/03	10	100	84.58	77.62	6.53^{DE}	24.76	152.42	67.83	11.55	49.11^{BC}	8.04^{C-E}	3.48^{F}	61.11
IBON/174/03	10	125	84.50	79.05	6.22^{E}	24.82	151.83	67.33	11.57	48.73^{BC}	10.17^{A-D}	4.86^{A-E}	60.69
Mean			84.76	78.05	7.07	25.18	152.25	67.49	11.57	50.00	9.53	4.58	61.01
Tukeys (HSD 0.05)			22.30^{NS}	9.17^{NS}	0.84**	3.44^{NS}	27.62^{NS}	6.21^{NS}	0.45^{NS}	2.62*	3.22**	1.38**	2.91^{NS}
CV			18.21	8.13	8.26	9.46	12.56	6.37	2.67	6.51	23.41	20.87	3.30

ns, * and ** insignificant, significant at p<0.05 and p<0.01, respectively. CV%: Coefficient of percent variation. DF: Degree of freedom, DD: Deterioration days, SR: Seed rate, DH: Days to heading, PH: Plant height, SL: Spike length, NSPS: Number of seed per spike, DM: Days to maturity, GFP: Grain filling periods, MC: Moisture content, TKW: Thousand kernel weight, AGDB: Above ground dry biomass, GYLD: Grain yield, HLW: Hector litter weight. Means in the same column followed by similar letters are not significantly different from each other at a 5% level of probability

Table 5: Pearson's correlation coefficients (r) between crop phenology, growth, yield, and yield-related parameters of malty barley variety

Traits	DH	PH	SL	NSPS	DM	GFP	MC	TKW	AGDB	GYLD	HLW
DH											
PH	−0.01^{ns}										
SL	−0.16*	0.41**									
NSPS	−0.44**	0.48*	0.43*								
DM	1.00**	0.02ns	−0.17*	−0.45**							
GFP	0.92**	−0.04^{ns}	−0.19**	−0.46**	0.95**						
MC	0.49**	0.70**	0.24**	0.22**	0.49**	0.44**					
TKW	0.56**	0.45**	0.04^{ns}	0.03^{ns}	0.55**	0.51**	0.74**				
AGDB	0.25**	0.39**	0.14*	0.13^{ns}	0.26**	0.25**	0.59**	0.65**			
GYLD	0.06^{ns}	0.52**	0.22**	0.27**	0.06^{ns}	0.05^{ns}	0.56**	0.59**	0.84**		
HLW	−0.40**	−0.59**	−0.26**	−0.14*	−0.40**	−0.34**	−0.74**	−0.41**	−0.24**	−0.25*	

ns **and * indicate non-significant, highly significant at 1%, and significant at 5% level of probability, respectively. DH: Days to heading, PH: Plant height, SL: Spike length, NSPS: Number of seeds per spike, DM: Days to maturity, GFP: Grain filling periods, MC: Moisture content, TKW: Thousand kernel weight, AGDB: Above-ground dry biomass, GYLD: Grain yield per hectare, HLW: Hectoliter weight

2nd year (8352.1 kg/ha) and the lowest mean density was obtained in 350 plants/m^2 in the 1st year (5559 kg/ha). Increasing biological yield in higher densities seems to be related to more fertile crops per unit area. With density increases, the biological yield linearly increases. For GYLD per hectare, Haile *et al*., 2013, also reported that the lower seed rate resulted in lower GYLD while higher yield was due to a higher seed rate. Moreover, this study is in agreement with the study by Abdulkerim *et al*., 2015, who reported that 30.66% increase in GYLD when the seeding rate was increased from 100 to 175 kg/ha in variety Digalu; 26.96 and 45% yield increase in case of variety Kakaba and Shorima, respectively, when the seed rate was increased from 100 to 150 kg/ha.

Correlation coefficients between crop phenology, growth, yield, and yield-related parameters of malty barley variety

The correlation between crop phenology, growth, yield, and yield-related parameters of the malty barley variety is presented in Table 5. These results showed that there were significant correlations between most of the crop phenology, growth, yield, and yield-related parameters of the malty barley variety. There was a highly significant difference ($p<0.01$) and a strong positive correlation between DM with DH (r=1), DH with GFP (r=0.92), DM with GFP (r=0.95), PH with MC (r=0.70), TKW with MC (r=0.74), and GYLD with AGDBM (r = 0.84).

Similarly, there was a highly significant difference ($p<0.01$) and moderately positive correlation between DH with TKW (r=0.56), PH with GYLD per hectare (r=0.52), TKW with DM (r=0.55), TKW with GFP (r=0.51), AGDBM with MC (r=0.59), GYLD with MC (r=0.56), AGDBM with TKW (r=0.65), and GYLD with TKW (r=0.59). On the other hand, there was a high negative correlation between HLW with MC (r=−0.74) and with PH (r=−59) whereas, the other parameters show significant, highly significant, non-significant, and weakly correlation as presented in Table 5.

CONCLUSION AND RECOMMENDATION

According to this study, the main effect of deterioration days showed a significant difference ($p<0.05$) for SL and a highly significant difference ($p<0.01$) for AGDBM and GYLD per hectare. On the other hand, the main effect of seed rate showed a significant difference ($p<0.05$) for the NSPS, TKW, and highly significant ($p<0.01$) for AGDBM and GYLD, whereas the interaction effect of deterioration days and seed rate was only significant for TKW and it was non-significant for the rest of evaluated crop phenology, growth, yield, and yield-related parameters.

SL was affected by deterioration days and as deterioration days progressed, the mean value for SL was reduced as compared to un-aged treatments. From the present study result, both the NSPS and the thousand kernels were influenced by seed rate but, not by deterioration days. As the seeding rate increased from 75 to 125 kg/ha, NSPS reduced by 4.75% whereas seeds sown by a low seeding rate (75 kg/ha) recorded a higher TKW as compared to the seed sown by higher seed rate 100 and 125 kg/ha. In addition, TKW was affected by the interaction of deterioration days and seed rate. Un-aged seed and sown by the three seeding rates recorded the highest value over the other treatment combination except, for the un-aged seed and sown by seed rate of 100 kg/ha which recorded almost similar results with the other combination. Moreover, both above-ground biomass and GYLD per hectare were highly affected by the main effect of aging and seed rate. As deterioration days increased, the mean value for AGDBM and GYLD per hectare was significantly reduced. Concerning seed rate for these two parameters as the seeding rate increased from 75 to 125 kg/ha AGDBM and GYLD per hectare increased by 30.53 and 21.01, respectively.

In general, from the present study, crop phenology, like DH, DM, and GFP, and from yield and yield-related parameters MC and HLW are not affected by aging and seed rate whereas, most of the other growth, yield, and yield-related parameters are influenced by aging and seed rate. This study missed evaluating the laboratory seed quality parameters, and it is necessary to conduct the experiments considering both field and laboratory variables and testing correlation to understand their relationship to make a conclusive recommendation.

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