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Seed Rate and Sowing Method Effects on Seed Quality of Bread Wheat (*triticum aestivum* L.) Varieties in Horo District, Western Ethiopia

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ABSTRACT

Although wheat varieties were released with recommended seed rates, farmers usually apply their specific seed rates for various reasons. A study was conducted in Horo District to determine the effect of seeding rate and sowing methods on the seed quality of bread wheat using field and laboratory experiments, in the 2011 cropping season. The field experiment was conducted at Shambu, Bako agricultural research center sub-site while the seed quality analysis was performed at seed laboratory of Holetta Agricultural Research Center. The field experiment consisted of three factors in a factorial combination of two levels of variety (Molgo which is local and Digelu or HAR-3116 which is an improved one), two levels of sowing methods (broadcast and row) and four levels of seed rate (125, 150, 175 and 200 kg/ha) arranged in RCBD with three replications. Samples of harvested seed from those treatment combinations were subjected to seed quality analysis according to procedures described by ISTA 2003. The result of Seed quality analysis showed that physical purity, standard germination, the speed of germination, vigor index-I and II, and field emergence index were significantly affected by treatment effects. All these parameters were higher in Digelu than in Molgo at the lowest seed rate (125 kg/ha) studied in row except the mean value of speed of germination which was higher for Molgo at a seed rate of 150 kg/ha. Six fungi and one bacterium species were associated with the seed samples studied. The results indicated that good quality seed was produced when both varieties were sown in row at a seed rate of 125 kg/ha. Moreover, variety Digelu was better in terms of seed quality than variety Molgo at all seed rates and both sowing methods.

Key words: Bread wheat, seed rate, sowing method, seed quality, seed health

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INTRODUCTION

Ethiopia is the second largest producer of wheat in Sub-Saharan Africa, following South Africa (White *et al*., 2001). Wheat is an important cereal crop in Ethiopia; it ranks third in terms of area after tef and maize, and second after maize in terms of productivity (FAO, 2005). However, the productivity of wheat in Ethiopia is much lower than the yields of other wheat producing countries of the world (White *et al*., 2001). The Poor genetic potential of varieties and the use of inadequate seed quality are some of the reasons for low productivity of the crop. Seed is the most important agricultural input, and it is the basic unit for distribution and maintenance of plant population (Mugonozza, 2001). It carries the genetic potential of the crop plant and thus dictates the ultimate productivity of other inputs (Ashagre and Ermias, 2007). Although; high- quality seed enhances the productivity and production of a given crop, and it have been attained through the use of recommended packages and other seed crop management practices, bread wheat seed producing farmers in Horo district, western Ethiopia do not use the seed rate recommended by researchers as they usually use higher seed rate and also they grow wheat in traditional hand broadcast sowing method. Thus, the use of high seed rate and traditional sowing method affect the quality of the seed. Yet, there is no information on the effect of seed rate and sowing method on seed quality of bread wheat in the study area. Therefore, the objective of this study was to investigate the effect of seed rate and sowing method on seed quality of bread wheat varieties in Horo District, western Ethiopia.

MATERIALS AND METHODS

The field experiment was conducted at Shambu, experimental site of Bako Agricultural Research center in Horo District in the 2011 main cropping season. The experiments consisted 16 treatments as factorial combination of two varieties Digelu (improved) and Molgo (local), four seeding rates (125,150,175 and 200 kg/ha) and two sowing methods (row and broadcasting) arranged in a randomized complete block design (RCBD) with three replications. The net plot size for data collection was 3.6m^2 (1.2m x 3m) from the total plot area of 8m^2 (2m x 4m). The distance between two rows was 20 cm while the distance between blocks and plots were 1.5m and 0.5m, respectively. The experimental field was prepared using oxen power and plowed four times, leveled manually and seed plots were prepared according to farmers' cultural practice and planting was done by hand. The recommended fertilizer rates of 64 kg N/ha and 46 kg P_2O_5/ha were used and 32 kg/ha N and 46 kg/ha P_2O_5 were applied at the time of planting while the remaining 32 kg/ha N was applied at mid tillering stage.

Laboratory Data Collection

Samples of harvested seed were subjected to seed quality analysis including physical quality (purity analysis and determination of thousand seed weight), seed moisture content analysis, physiological quality (standard germination test, seedling shoot and root length, seedling dry weight, vigor index-I and vigor index-II, speed of germination test and field emergence index and seed health test at Holetta Agricultural Research Center. All tests were performed according to procedures described by ISTA (2003).

Data Analysis

The analysis of variance (ANOVA) was computed for the laboratory parameters using the SAS software, version 9.0 (SAS, 2002). The mean comparison was done using least significant difference (LSD) test at 5% level of significance. Pearson correlation coefficient analysis was performed to determine the degree of association of physiological quality parameters.

RESULTS AND DISCUSSION

The main attributes of quality considered in this study were seed moisture content, physical purity, physiological quality, and seed health quality. Samples of harvested seed from different treatment combinations were subjected to seed quality analysis and accordingly interpreted. The discussions are given in the following sections.

Physical purity

There were significant differences in purity of seeds between the two varieties compared. The main effect of variety significantly ($P \leq 0.01$) affected the purity of harvested seeds while the other treatments combination did not significantly affected the parameter. Even if all treatment combinations met the national seed standards of Ethiopia (97%), the highest mean value of pure seed was obtained from the improved variety (Digelu or HAR 3116) than the local (Molgo) variety. Likewise, there was slight decrease of mean value of pure seed as the seed rates increased from 150 to 200 kg/ha, but sowing method did not show significant effect (Table 1).

Analysis of variance showed that all main effects and interaction effects of treatment combinations did not significantly affect the percent of the inert matter in the seed samples. Thus, seed samples from all treatment combinations had minimal impurities and met the maximum prescribed standards ($\leq$ 2%) described by QSAE (2000) for certified seed (Table 1). Both main effects of variety and seed rate, and their interaction effects significantly ($P \geq 0.05$) affected the presence of other crop seeds in the harvested seed samples. The highest mean value of other crop seed was observed for both varieties when they were sown at the seed rate of 200 kg/ha; but all combinations met the national standards (0.1%) except when local variety sown at 200 kg/ha seeding rate (Table 4). The other crop seed found in the sample was only barley that could be due to morphological similarities during growing seasons of the crops. In line with this finding, Zewdie (2004) reported that about 69.8% of the wheat seed samples were contaminated with barley crop.

Table 1: Main effect of varieties, sowing method and seed rate on seedling dry weight, fresh ungerminated seeds, vigor index-II, seedling shoot length, dead seeds, field emergence, pure seed and inert matter of wheat grown in Horo District during 2011 cropping season

Treatments	Parameters							
Varieties	**SDW (g)**	**FUS (%)**	**VII**	**SHL (cm)**	**TSW (g)**	**FE**	**PS (%)**	**IM (%)**
Molgo	0.238	2.13(6.88)	17.19	6.46	42.47	3.22	99.19	0.92 (0.36)
Digelu	0.261	0.93(0.63)	25.72	10.08	38.05	5.28	99.71	0.87 (0.26)
LSD (5%)	0.007	0.61	1.32	0.57	1.07	0.16	0.18	Ns
Sowing methods								
Broadcast	0.243	1.67 (4.63)	20.59	7.77	42.23a	4.13	99.45	0.91 (0.34)
Row	0.256	1.38(2.88)	22.32	8.76	40.83a	4.37	99.45	0.87 (0.27)
LSD (5%)	0.006	Ns	1.32	0.56	39.13b	0.16	Ns	Ns
Seed rates (kg/ha)					38.83b			
125	0.274a	0.79(0.25)b	25.77a	9.76a	1.07	4.66a	99.52	0.87 (0.25)
150	0.261b	1.29(2.13)ab	23.23b	8.75b		4.45a	99.55	0.87 (0.25)
175	0.239c	1.88(5.88)a	19.64c	7.59c	40.50	4.15b	99.42	0.89 (0.31)
200	0.223d	2.15(6.75)a	17.19d	6.94c	40.01	3.73c	99.32	0.95 (0.41)
LSD (5%)	0.009	0.86	1.87	0.81	ns	0.23	Ns	Ns
CV (%)	5.43	79.13	12.26	13.79	4.49	6.49	0.25	10.59

SDW= seedling dry weight, FUS= fresh ungerminated seeds, VII= vigor index two, SHL= seedling shoot length TSW= thousand seed weight, FE= field emergence, PS= pure seed, IM= inert matter, Means followed by the same letter along column are not significantly different from each other at 5% probability level. Percentage values were arc-sine transformed and values in parenthesis are the original value in percentage.

Weed seeds contamination significantly ($P \leq 0.01$) affected by the main effects of variety, interaction effects of seed rate x sowing method and the three-way treatments interaction (Table 2). Similarly, the parameter was significantly ($P \leq 0.05$) affected by the interaction of variety x sowing method. On the other hand, the main effects of seed rate and sowing method as well as the interaction effects of variety x seed rate did not significantly affect the percent of weed seeds in the samples.

Table 2: Interaction effects of variety x seed rate x sowing methods on weed seeds of wheat grown in Horo District during 2011 cropping season

Treatments			Parameter
Varieties	**Sowing methods**	**Seed rates (kg/ha)**	**Weed seeds (%)**
Molgo	Broadcast	125	0.87(0.27)cd
		150	0.85(0.22)de
		175	1.07(0.65)a
		200	0.89(0.29)cd
	Row	125	1.06(0.62)a
		150	1.02(0.53)ab
		175	0.94(0.38)bc
		200	0.93(0.36)cd
Digelu	Broadcast	125	0.71(0.00)f
		150	0.72(0.02)f
		175	0.73(0.03)f
		200	0.77(0.09)ef
	Row	125	0.72(0.10)f
		150	0.72(0.02)f
		175	0.73(0.04)f
		200	0.71(0.01)f
LSD (5%)			0.08
CV (%)			4.62

Means followed by the same letter along the column are not significantly different from each other at 5% probability level. Percentage values were arc-sine transformed, and values in parenthesis are the original value in percentage.

The higher mean values of weed seed were observed for the local variety over the improved one. This could be due to the association of weed seeds with local variety from the source at the time of sowing. Therefore, samples from all treatments combinations did not met the national maximum (≤ 0.02) weed seed standard for local variety while four treatment combination met the national standards out of eight treatment combinations for the improved variety. This could be due to weeds growth from the field with the crop (Table 2). The weeds species contaminate identified were *Avena* spp. and *Lolium temulentum.* This agrees with the work of Kolk (1979) who stated that *Avena* spp. and *Lolium temulentum* were the two most important weeds in wheat and barley cultivation in Ethiopia.

Thousand seed weight

Thousand seed weight is an important yield determining component which is reported to be a genetic characteristic of a plant and therefore, less affected by environmental factors (Ayoub *et al*., 1994). Analysis of variance revealed that main effects of variety and seed rate significantly ($P \leq 0.01$) affected thousand seed weight. Similarly, interaction effects of varieties and sowing methods significantly ($P \leq 0.05$) affected, but main effect of sowing method, interaction effects of variety x seed rate, seed rate x sowing method and three-way treatments interaction did not significantly ($P \geq 0.05$) affect thousand seed weight of bread wheat (Table 8).

Significantly higher mean thousand seed weight was obtained from Molgo over Digelu variety (Table 1). This could be due to genotypic difference between the two cultivars. Concerning the main effect of seed rate, the highest and lowest values of thousand seed weight were observed at 125 and 200 kg/ha, seed rates, respectively which was statistically significant and there was substantial decrease in mean value of the parameter as the seed rate increased from 125 to 200 kg/ha (Table 1). The two ways interaction of variety x sowing method indicated that, variety Molgo produced seeds with higher seed weight than Digelu in broadcast and row sowing method but the highest mean value of thousand seed weight was obtained from plants sown in row than that of broadcasted in both varieties (Table 1). In conformity with this result, Jan *et al.* (2000) who reported that as the seeding rate increased, the number of plants emerged per unit area also increased but thousand seed weight decreased. Ayaz *et al*. (1999) also reported that row spacing had significant effects on thousand seed weight.

Moisture content

Analysis of variance revealed that the main effect of variety, sowing method and interaction effect of varieties x sowing method significantly ($P \leq 0.05$) affected the moisture content of the harvested seeds. On the other hand, main effects of seed rate, interaction effect of variety x seed rate and sowing method x seeding rate and the three-way treatment combinations were not significant (Table 8). All the samples met the national standard for maximum wheat seed moisture content which is 13% (Table 3). The higher mean value for the parameter was recorded when Molgo variety was sown in broadcast sowing method, while the rest of the treatment interaction effects did not show significant difference among each other (Table 3).

Table 3: Interaction effect of varieties x sowing method on moisture contents, seedling shoot and root length of wheat grown in Horo District during 2011 cropping season

Treatments		Parameter		
Varieties	**Sowing methods**	**Moisture content (%)**	**SHL(cm)**	**RL(cm)**
Molgo	Broadcast	10.93a	5.51c	10.91c
	Row	10.08b	7.38b	12.78b
Digelu	Broadcast	10.09b	10.02a	16.14a
	Row	10.12b	10.13a	16.06a
LSD (%5)		0.50	1.12	1.36
CV (%)		5.46	13.79	7.79

Means followed by the same letter along the column are not significantly different from each other at 5% probability level.

Standard germination

The percentage of normal seedlings, abnormal seedlings, fresh ungerminated seeds and dead seeds of different seed samples under laboratory test were recorded. The proportion of normal seedlings were significantly ($P \leq 0.01$) affected by the main effects of variety and seed rate, and by the interaction effect of variety x seed rate. However, the main effect of sowing method and the interaction effect of variety x sowing method, seed rate x sowing method and the three-way treatments interaction did not significantly ($P \geq 0.05$) affect percent of standard germination (Table 7).

The highest mean values of normal seedlings were observed when the improved variety was sown at the seeding rates of 125 kg/ha while the lowest mean value was recorded when the local variety was sown at the seed rate of 200 kg/ha (Table 4). Generally, as the seeding rate increased from 125 to 200 kg/ha, the percent of standard germination declined for both varieties (Table 4).

Likewise, there were significant differences in number of normal seedlings among the improved and local varieties. This could be due to poor genetic potential of the local variety for germination. So, according to this study, only the improved variety in all combinations and local variety sown at 125 kg/ha seeding rate met the national standards of normal seedlings (85%) for a certified seed (Table 4).

Table 4: Interaction effects of varieties x seed rate on vigor index-II, speed of germination, normal and abnormal seedlings and other crop seed of wheat grown in Horo District during 2011 cropping season

Treatments		Parameters				
Varieties	**Seed rates (kg/ha)**	**VII**	**SPG**	**NS (%)**	**AB (%)**	**OCS (%)**
Molgo	125	23.17cd	13.47c	87.75b	18.92(11.25)c	0.72(0.01)b
	150	19.20e	14.21c	77.25c	23.91(18.00)bc	0.71(0.00)b
	175	14.29f	8.52d	63.75d	28.88(24.00)ab	0.71(0.00)b
	200	12.09f	7.95d	55.50d	33.46(31.00)a	0.81(0.16)a
Digelu	125	28.38a	24.78a	100.00a	0.00(0.00)d	0.71(0.00)b
	150	27.23ab	24.59a	99.00a	1.44(0.50)d	0.71 (0.00)b
	175	25.00bc	23.36ab	98.50a	2.89(1.00)d	0.71(0.00)b
	200	22.29d	22.46b	97.00ab	1.44(0.50)d	0.71(0.01)b
LSD (5%)		2.65	2.03	9.67	6.10	0.05
CV (%)		12.26	10.17	11.98	72.99	4.22

VII= vigor index two, SPG= speed of germination, NS= normal seedlings, AB= abnormal seedlings, OCS= other crop seeds. Means followed by the same letter along column are not significantly different from each other at 5% probability level. Percentage values were square root transformed and values in parenthesis are the original value in percentage.

The main effects of variety and seed rate, and the interaction effects of variety x seed rate highly significant ($P \leq 0.01$) effect on percentage of abnormal seedlings. But, the main effect of sowing method and the interaction effects of variety x sowing method, seed rate x sowing method and the three way treatments interaction did not significantly affected the parameter (Table 7).

The highest mean value of abnormal seedlings was obtained when the local variety was sown at the seeding rate of 200 kg/ha and generally the percent of abnormal seedlings for both varieties increased as the seeding rates increased from 125 to 200 kg/ha even though significant rise was observed only for the local variety (Table 4).

The proportion of fresh ungerminated seeds was significantly ($P \leq 0.01$) affected by the main effects of variety and seed rate while the main effect of sowing method and all interaction effects of treatments combination were not significant (Table 8). Percent value of fresh ungerminated seeds were higher in the local variety (Molgo) than in the improved one, and the values were increased as the seed rate increased from 125 to 200 kg/ha (Table 1).

The main effects of variety, seed rate and sowing method, and the interaction effects of variety x seed rate, variety x sowing method, seed rate x sowing method and the three-way treatments interaction were not significant ($P \geq 0.05$) in affecting percentage of dead seeds (Table 8).

Speed of germination

Analysis of variance indicated that the main effect of variety, seed rate and the interaction effect of variety x seed rate highly significantly ($P \leq 0.01$) affected the speed of germination. But, the main effect of sowing method, interaction effects of variety x sowing method, seed rate x sowing method and the three-way treatments interaction were not significant (Table 7).

The highest and lowest mean values were obtained when Digelu was sown at 125 kg/ha seeding rate and when Molgo was sown at 200 kg/ha seeding rate, respectively. Generally, Digelu provide higher speed of germination values than Molgo variety (Table 4). The speed of germination indicates the rate at which the seeds are germinating rapidly and seedling can emerge and fugitive adverse field conditions (Tekrony and Egli, 1991). Seeds that have high germination speed were found vigorous in the field and could be escaped harsh conditions.

Seedling vigor

The main limitation of germination test is its inability to detect quality differences among seed samples at high germination percentages and failure to predict field emergence under adverse field conditions for example in wheat (Vieira *et al.*, 1999 and Perry, 1980). Several physiological tests such as standard germination, seedling shoot, and root length, and seedling dry weight were considered to assess the vigor of bread wheat seed harvested from different treatment interactions.

Seedling shoot length

Seedling shoot length was significantly ($P \leq 0.01$) affected by all main effects of treatment factors. Similarly, the interaction effects of variety x sowing method significantly ($P \leq 0.05$) affected seedling shoot length but the interaction effects of seed rate x sowing method, variety x seed rate and the three way interactions were not significant (Table 7). In the interaction of varieties x sowing method, seed samples from Digelu produced longer shoot than Molgo (Table 3). Furthermore, Seed samples from plants sown in rows developed longer shoot than that of broadcasted but only significant in Molgo variety (Table 3). The highest mean value of shoot length was obtained from the seed samples sown at the seeding rate of 125 kg/ha while the minimum value was obtained from the seed sample sown at seeding rate of 200 kg/ha (Table 1). This could be because plants sown at lower seed rate bear nutritionally well-developed seeds since minimum competition for space, nutrients and light among individual plants during the growth and development of the crop. Zewdie, 2004 reported 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.

Seedling root length

Seedling root length was significantly ($P \leq 0.01$) affected by all main effects of treatment factors. Likewise, the parameter was significantly ($P \leq 0.05$) affected by the interaction effect of variety x sowing method and seed rate x sowing method while the interaction effect of variety x seed rate and the three-way treatments interaction were not significant (Table 7). Root length of seed samples from improved variety of bread wheat was longer than the local variety in both sowing methods. However, significant difference was observed between sowing methods only for the Molgo variety (Table 3). The longest root length was obtained from sample of bread wheat sown in broadcast at 125 kg/ha seed rate while the shortest roots observed from seed samples of bread wheat sown in broadcast at 200 kg/ha (Table 5). 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 by (Zewdie, 2004).

Table 5: Interaction effects of sowing method x seed rate on seedlings root length of wheat grown in Horo District during 2011 cropping season

Treatments		Parameter
Sowing methods	**Seed rates (kg/ha)**	**RL(cm)**
Broadcast	125	16.28a
	150	13.48bc
	175	12.53c
	200	11.83c
Row	125	15.98ab
	150	15.67ab
	175	13.58bc
	200	12.46c
LSD (5%)		2.56
CV (%)		7.79

RL= seedling root length, Means followed by the same letter along the column are not significantly different from each other at 5% probability level.

Seedling dry weight

Seedling dry weight was significantly ($P \leq 0.01$) affected by all main effects of treatment factors, but the parameter was not significantly affected by all interaction of treatments (Table 7). The higher mean value of seedling dry weight was obtained from Digelu when compared with Molgo. Concerning sowing method, more seedlings dry weight was observed from sample of treatments sown in rows than broadcast, which was statistically significant. The highest and lowest mean value of seedling dry weight were obtained from treatments sown at the seed rate of 125 and 200 kg/ha, respectively (Table 1).

Seedling vigor index-I

Seedling vigor index-I was significantly ($P \leq 0.01$) affected by the main effect of variety, seed rate and sowing method. Likewise, the interaction effect of variety x seed rate and variety x sowing method showed significant ($P \leq 0.05$) effect on the parameter. Seedling vigor index I was not significantly affected by the interaction effect of seed rate x sowing method and three-way treatments interaction (Table 8).

Table 6: Interaction effect of varieties x seed rate and sowing method on vigor index-I of wheat grown in Horo District during 2011 cropping season

Treatments	**Mean values**	
	Varieties	
Seed rates (kg/ha)	**Molgo**	**Digelu**
125	2021.7d	2886.3a
150	1526.2e	2695.6ab
175	1046.0f	2469.6bc
200	828.00f	2286.8cd
LSD (5%)	301.32	
Sowing methods		
Broadcast	1179.72d	2567.09b
Row	1531.23c	2902.05a
LSD (5%)		322.63
CV (%)		14.43

Means followed by the same letter along column are not significantly different from each other at 5% probability level.

The highest mean value of vigor index-I was obtained from the seed sample of Digelu variety sown at 125 kg/ha seeding rate while sample from Molgo sown at 200 kg/ha seeding rate produced the lowest mean value of vigor index-I (Table 6). The mean values of vigor index-I were decreased as the seeding rate increased for both varieties and no significant difference was observed between seed rate of 125 and 150 kg/ha for Digelu variety and 175 and 200 kg/ ha for both varieties (Table 6). Due to the interaction of variety x sowing method, higher mean value of vigor index-I was recorded for the Digelu variety sown in rows and the lower mean value was obtained from the sample of local bread wheat variety sown in broadcast (Table 6).

Seedling vigor index-II

Seedling vigor index-II was significantly ($P \leq 0.01$) affected by main effects of variety and seed rate. Similarly, the main effect of sowing method and the interaction effect of variety x seed rate significantly ($P \leq 0.05$) affected vigor index-II. But the interaction effects of variety x sowing method, seed rate x sowing method and three-way treatments interaction were not significant (Table 8).

The highest mean value of seedling vigor index-II was obtained from the seed sample of Digelu sown at seeding rate of 125 kg/ha in the field followed by the same variety sown at 150 and 175 kg/ha, respectively. The minimum value was obtained from the seed sample of Molgo sown at 200 kg/ha seeding rate. Regarding to the main effect of sowing method, the higher mean value of seedling vigor index-II was obtained from seed sample of bread wheat sown in rows than broadcasted (Table 1 and 4). Gore *et al.* (1997) reported that higher seedling vigour index II was probably due to the associated effect of germination percentage and seedling length.

Field emergence index

Analysis of variance showed that the main effect of variety, seed rate and sowing method significantly ($P \leq 0.01$) affected field emergence index of bread wheat seed harvested from different treatments while the effect of all treatments interaction were not significant (Table 8). Digelu variety showed higher field emergence index than Molgo variety and samples from treatments sown in rows produced higher value than that of broadcasted. The highest field emergence value was obtained from the sample of treatments sown at 125 kg/ha followed by 150 and 175 kg/ha, but the lowest value was observed at 200 kg/ha seeding rate (Table 1).

Table 7: ANOVA for laboratory parameters of wheat grown in Horo District during main cropping season of 2011

Sources	Df	SDW	SPG	SHL	RL	NS	ABS
Varieties	1	0.0081**	2605.46**	210.79**	290.02**	12155.06**	9877.9(6765.06)**
Seed rate	3	0.0080**	74.30**	24.91**	48.97**	960.06**	201.4 (301.73)**
Sowing method	1	0.0028**	12.54^{ns}	15.71**	12.76**	138.06ns	50.3 (33.06) ^{ns}
Varieties*Seed rate	3	0.0003^{ns}	20.24**	3.17^{ns}	1.03^{ns}	685.56**	124.7 (267.73)**
Varieties*Sowing method	1	0.0003^{ns}	6.19^{ns}	12.56*	15.13*	45.56^{ns}	1.8 (14.06)^{ns}
Seed rate* Sowing method	3	0.0002^{ns}	12.15 ^{ns}	0.90^{ns}	4.27*	4.56^{ns}	27.9 (24.73) ^{ns}
Varieties*Seed rate*Sowing method	3	0.0001^{ns}	7.96^{ns}	0.25^{ns}	0.55^{ns}	21.39^{ns}	36.3 (25.73) ^{ns}
Error	48	0.0002	3.14	1.29	1.19	103.27	38.18 (61.94)
Total	63						
CV (%)		5.43	10.17	13.79	7.79	11.98	44.56

*, ** = Significant and highly significant difference at 5% and 1% probability level, respectively, ns = Not significantly different, Df= Degree of freedom, CV= Coefficient of variation, SDW= Seedling dry weight, SPG= Speed of germination, SHL= Shoot length, RL= Root length, NS= Normal seedlings, ABS=Abnormal seedlings, Percentage values were square root transformed and values in parenthesis are the original value in percentage.

Table 8: ANOVA for laboratory parameters of wheat grown in Horo District during main cropping season of 2011

Sources	Df	FUS	DS	VI	VII	MC	FE	TSW(g)
Varieties	1	22.86(625.0)** (625.00)**	0.96 (9.00)^{ns}	24170964.38**	1166.05**	1.92*	50.78**	12.62*
Seed rate	3	5.85 (151.50)**	0.39 (3.00)^{ns}	2503139.08**	230.45**	0.60^{ns}	1.94**	234.53**
Sowing method	1	1.36 (49.00)^{ns}	0.08 (1.00)^{ns}	597416.92**	47.99*	2.00*	0.69**	29.98**
Varieties*Seed rate	3	2.93 (107.17)^{ns}	0.03 (0.33)^{ns}	302685.44*	25.08*	0.66^{ns}	0.09^{ns}	2.95^{ns}
Varieties*Sowing method	1	0.01 (16.00)^{ns}	0.08 (1.00)^{ns}	400825.11*	4.79^{ns}	2.25**	0.02^{ns}	4.88^{ns}
Seed rate* Sowing method	3	0.31 (115.17)^{ns}	0.32 (3.00)^{ns}	44164.27^{ns}	0.12^{ns}	0.54^{ns}	0.02^{ns}	23.66*
Varieties*Seed rate*Sowing method	3	0.33 (12.83)^{ns}	0.32 (3.00)^{ns}	19154.79^{ns}	2.08^{ns}	0.64^{ns}	0.01^{ns}	1.07^{ns}
Error	48	1.5 (49.13)	0.28 (2.67)	80826	6.92	0.32	0.08	0.90^{ns}
Total	63							3.26
CV (%)		79.13	57.82	14.43	12.26	5.46	6.49	4.49

*, ** = Significant and highly significant difference at 5% and 1% probability level, respectively, ns = Not significantly different, Df= Degree of freedom, CV= Coefficient of variation, FUS= Fresh ungerminated seeds, DS= Dead seeds, VI= Vigor index-I, MC= Moisture contents, FE= Field emergence, Percentage values were arc-sine transformed and values in parenthesis are the original value in percentage.

Association of seed physiological quality parameters

The simple combined correlation analysis was performed for the measured variables of physiological quality parameters. The analysis result showed that presence of strong positive and significant ($P \leq 0.01$) association among seed physiological quality parameters (Table 9). Similarly, Zewdie (2004) reported that standard germination showed positive correlation with seedling root length, seedling dry weight, vigor index I and vigor index II; Correspondingly speed of germination, seedling root and shoot length showed highly significant and positive correlation with vigor index-I for bread wheat.

Table 9: Pearson's simple combined correlation coefficients of seed physiological quality parameters of bread wheat varieties tested under different seed rate and sowing method in Horo District during 2011 cropping season

Variables	SPG	SG	SHL	RL	VI	VII	SDW
SPG	1	0.848**	0.853**	0.838**	0.902**	0.845**	0.586**
SG		1	0.843**	0.825**	0.934**	0.944**	0.595**
SHL			1	0.933**	0.962**	0.872**	0.667**
RL				1	0.956**	0.878**	0.721**
VI					1	0.945**	0.689**
VII						1	0.819**
SDW							1

** = Significantly correlated at $P < 0.01$, SDW = Seedling dry weight, SPG = Speed of germination, RL = Root length, SHL = Shoot length, SG = Standard germination, I = Vigor index I, VII = Vigor index II

Seed health

The results of seed health assessment showed that six genera and two species of fungi, and one genus of bacteria were associated with the seed samples taken from treatments combination harvested from the field experiment. The most dominant fungi were *Fusarium* spp, *Cladosporium* spp and *Alternaria* spp; other fungi and bacteria were of minor occurrence (Table 10). The study is in line with Hulluka *et al.* (1991) who isolated 15 fungal species from wheat seed collected from farmers and experimental stations in central Ethiopia among which the genera of *Alternaria*, *Helminthosporium(Bipolaris)*, *Fusarium*, and *Phoma* were predominant. The Ethiopian seed certification standard (QSAE, 2000) requires the maximum permitted percent infection for seed-borne diseases to be zero for breeder/pre-basic seed, 0.02% for basic seed, 0.03% for certified 1, 0.05% certified 2, certified 3 and certified 4; and 0.1% for emergency seed. In this study, all the seeds samples did not meet the national seed standard of maximum infected percent for certified seeds. This could be due to the association of those fungi with seeds from the source and favorable climatic condition for the development of pathogens in the field during growth and development of the crop or contamination in the plot from where the crop was grown.

The health quality of bread wheat seed samples obtained from harvested treatments combination was checked for the presence of the seed-borne pathogen. The highest percent infection was by *Fusarium* spp (*Fusarium oxysporum* and *Fusarium moniliforme*) and *Cladosporium* spp. These fungal species were infecting both varieties sown in row and broadcast at different seeding rate in a similar manner (Table 10).

Bread wheat variety Molgo was more infected by pseudomonas than Digelu. The higher infection percent by *Alternaria* spp observed on Molgo variety. This might be due to its susceptibility and high moisture content of the seed that promoted the development of diseases. On the other hand, the highest percent infection was recorded in Molgo and Digelu by *Fusarium moniliforme* and *Fusarium oxysporum*, respectively (Table 10).

Seed-borne diseases are major crop production constraints in terms of reducing crop yield and seed quality. Many researchers (Bekele, 1985; Hailu *et.al.*1998). Paul *et al.* (1994) reported that *Alternaria, Cladosporium, Curvularia, Fusarium* and *Penicillium* were found to reduce root and shoot length. High rainfall in the study area, especially at the crop physiological maturity period, might have contributed to the highest occurrence and frequency of the identified seed-borne pathogens. Bekele and Karr (1997) reported that *Fusarium* head blight was identified as a major threat to wheat production in Ethiopia under high rainfall conditions that are favorable to the disease development.

Table 10: Mean percent of seeds infected by fungal species, on bread wheat seeds harvested from different treatments combination gown in Horo District during 2011 cropping season

Treatments			Associated Pathogens and mean percent of infected seeds								
Varieties	**Sowing methods**	**Seed rates (kg/ha)**	**FOX**	**FOL**	**CLD**	**PSD**	**ALT**	**CHA**	**PHO**	**EPI**	**BIP**
Molgo	Broadcast	125	21.7	60.0	38.3	6.7	15.0	5.0	0.0	5.0	0.0
		150	20.0	56.7	43.3	1.7	5.0	10.0	3.3	3.3	1.7
		175	33.3	43.3	31.7	0.0	1.7	0.0	3.3	0.0	5.0
		200	15.0	40.0	40.0	1.7	6.7	0.0	3.3	0.0	0.0
	Row	125	20.0	55.0	18.3	5.0	1.7	6.7	0.0	0.0	1.7
		150	25.0	40.0	38.3	3.3	0.0	0.0	0.0	5.0	5.0
		175	30.0	28.3	26.7	0.0	3.3	5.0	10.0	0.0	0.0
		200	11.7	31.7	28.3	0.0	3.3	6.7	21.7	0.0	5.0
Digelu	Broadcast	125	30.0	41.7	33.3	0.0	0.0	3.3	3.3	0.0	0.0
		150	18.3	26.7	50.0	3.3	0.0	0.0	5.0	0.0	0.0
		175	40.0	23.3	36.7	0.0	0.0	3.3	6.7	0.0	0.0
		200	25.0	28.3	40.0	0.0	5.0	5.0	3.3	5.0	3.3
	Row	125	13.3	28.3	48.3	5.0	6.7	0.0	6.7	0.0	0.0
		150	28.3	16.7	48.3	3.3	3.3	0.0	5.0	0.0	5.0
		175	18.3	35.0	45.0	0.0	5.0	5.0	3.3	0.0	3.3
		200	8.3	41.7	50.0	0.0	6.7	5.0	0.0	0.0	3.3
Mean			22.4	37.3	38.5	1.9	3.9	3.4	4.7	1.1	2.1

FOX= *Fusarium oxysporum*, FOL= *Fusarium moniliforme*, CLD= *Cladosporium* spp, PSD= Pseudomonas, ALT= *Altrnaria* spp, CHA= *Chaetomium* spp, PHO= *Phoma* spp, EPI= *Epicoccum* spp, BIP= *Bipolaris* spp.

Conclusion and Recommendations

Based on the results of this study, application of different seed rates and sowing methods had significant effects on seed quality of bread wheat. Overall, the results of the study showed that high-quality seed was obtained when both varieties are grown in rows at a seed rate of 125 kg/ha. As the seeding rate increased from 125 to 200 kg/ha the values of vigor-I, vigor-II, seedling dry weight, seedling shoot and root length, thousand seed weight, field emergence index, speed of germination and percent of pure seed and normal seedlings were declined for both varieties. The improved variety was better in terms of seed quality at all seeding rate and both sowing methods. Concerning seed health, the supply of quality seed is essential for the area. It is, also, important to consider seed processing and storage in the area to prevent seed-borne diseases and improve seed quality.

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