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# Effect of Seed Sources and Rates on Productivity of Bread Wheat (Triticum aestivum L.) Varieties at Kersa, Eastern Ethiopia

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**Abstract**
The experiment was conducted with the objectives of evaluating the effect of seeds sources, seed rates and varieties on yield and yield related traits and to determine seed quality of different sources of bread wheat varieties. This experiment consisted of laboratory and field experiments. The laboratory experiment was laid out as Completely Randomized Design (CRD) with four replications in factorial arrangement of two (Digalu and Qulqulluu) wheat varieties and 10 seed sources conducted at Haramaya University Seed Science and Technology laboratory. The analysis of experiments showed that the interaction of seed source and variety had significant effect on all physical and physiological seed quality parameters. The field experiment was laid out as Randomized Complete Block Design (RCBD) with three replications in factorial arrangement of two varieties, three seed sources (seeds obtained from Haramaya University, Kersa Local Seed Business Project and Farmers), and three seed rates (100, 125 and 150 kg ha$^{-1}$). The highest grain yield of (5.652 t ha$^{-1}$) and (5.162) recorded on plants seed obtained from Kersa Local Seed Business Project seed source and seed sown at the seed rate of 150 kg ha$^{-1}$, respectively. Thus, Qulqulluu variety seed obtained from Kersa Local Seed Business Project and seed rate of 150 kg ha$^{-1}$could be used to increase productivity of wheat. However, it is necessary to conduct the experiments considering more number of seed sources, seed rates and varieties at major wheat growing areas for more than one cropping seasons to make conclusive recommendation.
**Keywords**: Germination, Grain Yield, Physical Purity, Seed Vigour
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## 1. Introduction
Wheat *(Triticum aestivum* L.*)* is one of the most important world cereal crops and is a staple food for about one-third of the world's population (Hussain and Shah*,* 2002). It is major source of food grain and high adaptation of this crop as well as its diverse consumptions in the human nutrition lead to present, especially in developing countries (Farzi and Bigloo, 2010).It has the highest content of protein of all the staple cereals and contains essential minerals, vitamins, and lipids. It is the primary source of protein in developing countries where 1.2 billion people are dependent on wheat for survival (CIMMYT, 2011).It grown on 220 million hectares (Singh and Trethowan, 2007) constituting 15.4 percent of the world's arable land (more land area than any other crop) and it is grown in almost all countries and climates (Curtis, 2002).

World wheat production increased dramatically from 1951-1990, mainly due to an increase in grain yield per hectare rather than an increase in production area. In Eastern Africa, Ethiopia ranks first both in terms of area harvested (1,627,647 ha) and total wheat production (3,434,706 tons) (FAOSTAT, 2013). In 2013/2014 cropping season, out of the total grain crop area, 79.38% (9,848,745.96 hectares) was under cereals. From this area, wheat took up 13.52 % (1,677,486.33 hectares) of the grain crop area. Among cereals, wheat accounts for 15.60% (3,925,194 tons) grain (CSA, 2014). However, the productivity of the crop remains low (2.4 tons ha$^{-1}$) in the country as compared to the world average yield (3.19 tons ha$^{-1}$) (FAOSTAT, 2013). In east Hararghe total grain crop area in 2013/14 crop season was (202,717.60 hectares) and (447,174.2 tons) production was under cereals. From this area, wheat took up (19,935.77 hectares) and 15.60% (36,349.5 tons) (CSA, 2014).This low yield might be due to unavailability of adaptable varieties as well as the use of farmer saved poor quality seeds of local cultivars and use of inappropriate seed rates as a major problem. Thus, the study was conducted with the objectives to evaluate the effect of seed sources, seed rates and wheat varieties on yield and yield related traits, and to determine seed quality of different sources and its associations with yield and yield components of bread wheat varieties.

## 2. Materials and Methods
This study consisted of laboratory and field experiments.

### *2.1. Laboratory experiment*
#### *2.1.1. Experimental materials, treatment and design*
The twenty seed samples for two varieties (Qulqulluu and Digalu) each from ten seed sources [seed samples obtained from Haramaya University Wheat Research Program (HU), Kersa local seed business project (LSB), seeds obtained from farmers (F1 to $F_8$)] were collected and used as treatments (2 x 10 factorial arrangement) in four replications. The experiment was conducted at Haramaya University Seed Science and Technology laboratory, which was carried out as per International Seed Testing Association rules and procedures (ISTA, 2008). The

experiment was laid out as Completely Randomized Design (CRD).

*2.1.2. Seed physical and physiological quality test*

Both Seed physical (physical purity, seed moisture content and hundred kernel weights) and physiological (Standard germination, Seedlings shoot and root length (cm), Seedling dry weight (g), Seed vigor index I and Seed Vigor index II) quality attributes were tested according to ISTA (2008) procedure.

*2.2. Field experiment*

*2.2.1. Description of the experimental site*

The study was conducted at Kersa farmers' field during 2014 main cropping season from July to November 2014.Kersa is one of the Woredas of East Hararghe zone in the Oromia Regional state of Ethiopia. It was named after a river that flows through it, the Kersa. Kersa is bordered on the south by Bedeno, on the west by Meta, on the north by Dire Dawa, on the northeast by Haramaya, and on the southeast by Kurfa Chele. Kersa district is located at altitude ranging from 1,740 to 2,660 meter above sea level (m.a.s.l.). The mean annual rainfall is 1150 mm and the average annual temperatures ranged from $11.2^0$C to 29.6°C (Tsige Ketema and Ketema Bacha, 2013).

*2.2.2. Experimental materials*

The two varieties viz. Digalu and Qulqulluu seeds were collected from different seed sources that were used as experimental materials. The seeds were collected from three sources; (1) Haramaya University Wheat Research Program (HU) which considered as quality seeds, (2) Kersa Local Seed Businesses project (LSBs) from Kersa ISSD (Integrated Seed Sector Development) project station which represents certified seeds since the seeds were produced under close supervision and technical support of the project and (3) Farmers saved seeds from Kersa farmers. The seeds of the varieties from all sources were collected from the 2013/2014 cropping season harvest. The farmers saved seeds were collected from eight farmers each consisted two bread wheat varieties in equal proportions as two composite samples. Half of the collected seed samples for each variety were mixed and which was used as one source (farmers saved seed) for field experiment while the remaining half was kept as separate samples of each source was tested for seed quality in the laboratory.

*2.2.3. Treatments and experimental design*

The treatments were included two varieties (Digalu and Qulqulluu), three seed sources [HU, LSB and seeds from farmers] and three seed rates (100 kg $ha^{-1}$, 125 kg $ha^{-1}$ and 150 kg $ha^{-1}$) a total of 18 treatments. The experiment was laid out in randomized complete block design (RCBD) in 2 x 3 x 3 factorial arrangements with three replications. The size of each experimental plot was 3 m long and 2 m wide with 10 rows of 20 cm apart giving a gross plot area of 6 $m^2$. Spacing of 1 m and 0.5 m was maintained between adjacent blocks and plots, respectively. All data except phenology of the crop were collected from the middle eight rows leaving the outer most two rows in both sides and plants that were grown in 0.2 m extreme most distance at both ends of rows. Thus, the net harvestable plot area was 4.16 $m^2$ (2.6 m x 1.6 m).

*2.2.4. Management of experiment*

The experimental field was prepared following the conventional tillage practice. Sowing was done on July 25, 2014 by hand drilling in rows and covered lightly with soil (at the depth of 3-5 cm). All plots were received uniform fertilizer rates of full dose 100 kg DAP $ha^{-1}$ (46 kg $P_2o_5$ and 18 kg N) which was applied at sowing, while 100 kg Urea $ha^{-1}$ (46 kg N) was applied in to three splits (at sowing, mid-tillering and anthesis stage) as a source of nitrogen.

*2.3. Data collection and measurements*

The data of Phenological and growth parameters such as Days to 50% heading (DH), Days to 90% physiological maturity (DPM), Grain filling period (GFP) and Plant height (PH) and Yield components and yield parameters such as Number of tillers (NT), Number of productive tillers, Spike length (SL), Grain yield (GY), 1000 kernels weight (TKW), Biomass yield (BY) and Harvest index (HI) were collected and measured according to their procedures.

*2.4. Statistical analysis*

The data were subjected to analysis of variance (ANOVA) as per the experimental designs for each experiment using GenStat $15^{th}$ edition statistical software package. The Least Significance Difference (LSD) test at 5% level of probability procedure was used to determine differences between treatment means.

## 3. Results and Discussion

*3.1. Laboratory experiment*

*3.1.1. Seed physical purity test*

The analysis of variance results revealed that physical purity (%) was highly significantly ($P \leq 0.01$) influenced due to the main factor of seed source and interaction of seed source and variety but not by variety. Generally, both bread wheat varieties seeds obtained from Haramaya University Wheat Research Program and Kersa Local Seed

Business Project had the highest pure seeds percentage as compared to seed samples collected from farmers (table 1). However, none of the seed samples registered the minimum requirement set for certified seeds ($C_1$ to $C_4$) which ranged from 97 to 95%. The proportion of pure seeds recorded for Digalu variety was in agreement with the results of Girma (2012) who reported mean percentage of pure seed (98.82%) for the same variety seed samples collected from different sources and the lowest percent 90.72% pure seeds were recorded for wheat varieties seeds obtained from farmers. In this study, none of the seed samples obtained from different sources had 1% inert matter. This showed that all sample seeds had percent inert matter less than the minimum prescribed standard set by the Quality and Standards Authority of Ethiopia (QSAE, 2000) for pre-basic (breeder) seeds.

*3.1.2. Moisture content*

The highest seeds moisture content (13.65%) was recorded for Digalu variety seed sample obtained from farmer (F4) and (F1) and the lowest (11.05%) was for Qulqulluu variety seed obtained from Haramaya University Wheat Research Program. The result indicated that Digalu variety as compared to Qulqulluu had higher moisture content and had the ability to maintain high moisture content that takes longer time for drying of seed after harvest. This result was consistent with findings of Girma (2012) who reported that the mean percentage of moisture content between varieties across formal seed system was 11.4% and 11.9% for Galama and Digalu wheat varieties, respectively, while it was 11.9% and 13.2% for Galama and Digalu, respectively, for informal seed system.

Seed moisture content can tell about the physiological activities which are undergone within the seed while it was in the store or at harvest if the test was conducted within short period of time after harvest. According to "rule of thumbs" of Harington (1973), 1% reduction of seed moisture content doubles the storage life of the seeds. Therefore, even if the temperature and humidity are kept constant every 1% reduction in moisture content has an advantage of doubling the seed longevity. The regional quality report of United States hard red spring wheat ranges from 12 to 13 percent (RQR, 2013). In this experiment, most of the seed samples had moisture content <13% except few seed samples of Digalu variety obtained from farmers. Therefore, the seed samples are expected to be more stable during storage, more profitable to a miller and higher germination rates. Similar result was reported by Strelec *et al. (*2010) that the reduced seed moisture content increase longevity and higher germination rates with different storage temperatures and relative humidity of stored wheat seeds.

*3.1.3. Standard germination percentage*

The laboratory experiment showed normal germination of seed samples obtained from each sources and variety incubated for eight days. The growth of plumule and radicle started after four to the last eight days of incubation; the highest germination of seeds observed at four and five days of incubation, then no germination observed after six days. The normal, abnormal and dead seeds were evaluated from four to the last eight days of incubation. Analysis of variance for the data revealed that superiority of the seed obtained from Haramaya University Wheat Research Program and Kersa Local Seed Business Project over the farmer saved seeds in terms of germination percentage, abnormal seedling and dead seeds of bread wheat varieties. However, no variety of the sources recorded below minimum requirements germination percentage set by the Quality and Standards Authority of Ethiopia (QSAE, 2000) which was 85% for certified seed class 4.

The highest and lowest germination of seeds indicated that the highest and lowest potential of vigoursity of the seed. Farmer seed sources from each variety showed the lowest germination percentage and highest abnormal seed percentage as compared to HU and LSB sources (Table 1). An immature seed leads to increase abnormality of seedlings (mechanically damaged, broken seeds). The normal seedling growth in the laboratory obtained from mature endosperm of food storage, because after germination seedlings use the endosperm food for growth and development. The higher food reserve in the endosperm results higher kernel weight and leads to vigorous crop in the field. This result was in agreement with the results reported by Abdul *et al.* (2014) that the bread wheat variety sown with bolder seeds resulted in significantly higher seed germination of 95.29% as compared to the wheat variety sown with small sized seeds with 91.70% germination.

*3.1.4. Seedling length and dry weight*

The analysis of variance results indicated that the highest seedling length (28.08 cm) was recorded for seed sample of Qulqulluu seed obtained from Kersa Local Seed Business Project (LSB) and the lowest seedling length (23.00 cm) was recorded for seed sample of Digalu variety seed obtained from two farmers (F2 and F3). Variety Qulqulluu seed sample obtained from LSB had well-developed shoot and root systems that can withstand any adverse conditions and provide better seedling emergence and seedling establishment in the field. This result was in agreement with the findings of Gharineh and Moshatati (2012) who reported that more seedling length and seedling dry weight of the heavy seeds might be attributed to large food reserves of the seeds. The seed source and the interaction between seed source and variety had significant effect on seedling dry weight. The highest seedling dry weight (0.01762 g) was recorded for Qulqulluu variety seeds obtained from Kersa Local Seed Business Project and the lowest seedling dry weight (0.01358 g) was recorded for Digalu variety seeds obtained from farmer two (F2). Similarly, by Zareian *et al.* (2013) reported that large seed size produce higher seedling dry weight and it was noticed that seedling dry weight in large seed sizes was related to more seed food storage in their endosperms.

*3.1.5. Seedling vigour index*

The result indicated in both cases (seed vigour-I and II), farmers saved seeds had lower seedling vigour index one and two as compared to Haramaya University Wheat Research Program (HU) and Kersa Local Seed Business Project (LSB) seed samples (table 1). This is due to its lower standard germination percentages, hundred kernel weight, seedling length and dry weight of farmers saved seeds. Similarly, Basra (2002) reported that practical seed vigor test should give a good indication of field performance potential of the seed lot and the test results should be reproducible.

Table 1. Interaction effect of different seed sources and varieties on seed physical purity, standard germination percentage, abnormal seed, seed vigour index one and seed vigour index two.

| Traits | PSP | | SGP | | ABS | | SVI- I | | SVI- II | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variety<br>Seed Source | Qulqulluu | Digalu | Qulqulluu | Digalu | Qulqulluu | Digalu | Qulqulluu | Digalu | Qulqulluu | Digalu |
| HU | 99.78$^{ab}$ | 99.86$^{a}$ | 97.50$^{ab}$ | 98.25$^{a}$ | 1.50$^{de}$ | 1.75$^{cd}$ | 26.14$^{cd}$ | 26.93$^{b}$ | 0.01418$^{c-f}$ | 0.01620$^{ab}$ |
| LSB | 99.79$^{ab}$ | 99.78$^{ab}$ | 98.25$^{a}$ | 98.25$^{a}$ | 1.00$^{e}$ | 1.75$^{cd}$ | 27.59$^{a}$ | 26.66$^{bc}$ | 0.01731$^{a}$ | 0.01621$^{ab}$ |
| F1 | 99.40$^{i}$ | 99.69$^{bcd}$ | 96.50$^{cde}$ | 97.50$^{ab}$ | 2.50$^{ab}$ | 1.50$^{de}$ | 25.48$^{ef}$ | 25.74$^{de}$ | 0.01399$^{c-f}$ | 0.01516$^{bc}$ |
| F2 | 99.49$^{ghi}$ | 99.25$^{j}$ | 97.25$^{bc}$ | 96.75$^{bcd}$ | 2.25$^{abc}$ | 2.25$^{abc}$ | 26.68$^{bc}$ | 22.25$^{i}$ | 0.01407$^{c-f}$ | 0.01314$^{f}$ |
| F3 | 99.64$^{c-f}$ | 99.55$^{fgh}$ | 97.00$^{bcd}$ | 97.00$^{bcd}$ | 2.00$^{bcd}$ | 2.25$^{abc}$ | 24.01$^{g}$ | 22.54$^{hi}$ | 0.01454$^{c-f}$ | 0.01359$^{c-f}$ |
| F4 | 99.30$^{j}$ | 99.45$^{hi}$ | 96.50$^{cde}$ | 96.62$^{b-e}$ | 2.50$^{ab}$ | 2.25$^{abc}$ | 23.61$^{g}$ | 25.66$^{de}$ | 0.01352$^{def}$ | 0.01400$^{c-f}$ |
| F5 | 99.72$^{bc}$ | 99.58$^{fgh}$ | 97.00$^{bcd}$ | 96.25$^{de}$ | 1.50$^{de}$ | 2.50$^{ab}$ | 25.22$^{ef}$ | 24.96$^{f}$ | 0.01406$^{c-f}$ | 0.01347$^{ef}$ |
| F6 | 99.66$^{cde}$ | 99.73$^{bc}$ | 95.75$^{e}$ | 97.25$^{bc}$ | 2.25$^{abc}$ | 2.00$^{bcd}$ | 22.40$^{hi}$ | 26.49$^{bc}$ | 0.01436$^{c-f}$ | 0.01361$^{c-f}$ |
| F7 | 99.55$^{fgh}$ | 99.46$^{hi}$ | 96.25$^{de}$ | 96.75$^{bcd}$ | 2.50$^{ab}$ | 2.00$^{bcd}$ | 23.93$^{g}$ | 24.01$^{g}$ | 0.01491$^{b-e}$ | 0.01354$^{c-f}$ |
| F8 | 99.70$^{bc}$ | 99.59$^{d-g}$ | 95.75$^{e}$ | 97.50$^{ab}$ | 2.75$^{a}$ | 1.50$^{de}$ | 22.95$^{h}$ | 26.21$^{cd}$ | 0.01340$^{ef}$ | 0.01510$^{bcd}$ |
| LSD (5%) | 0.101 | | 0.93 | | 0.73 | | 0.55 | | 0.001619 | |
| CV (%) | 0.1 | | 0.7 | | 25.5 | | 1.5 | | 7.9 | |

Means with the same letter(s) in the same column of each trait are not significantly different at 5% probability level, LSD (5%) = least significant difference at 5% probability level, CV (%) = coefficient of variation in percent, HU = seed obtained from Haramaya University Wheat Research Program, LSB = seed obtained from Kersa Local Seed Business Project, F1 to F8 = seed samples collected from Farmer one to Farmer eight, PS= pure seed percentage, SGP= standard germination percentage, ABS= abnormal seedling, VI- I = seedling vigour index one and SVI- II = seedling vigour index two.

*3.2. Field experiment*

*3.2.1. Days to heading*

Days to 50% heading was significantly ($P<0.01$) affected by the main factor of variety and seed rate and interaction effect of variety and seed source. The delayed in days to 50% heading (71.33 days) was recorded for Digalu variety seeds obtained from Haramaya University sown at seed rate of 100 and 125 kg ha$^{-1}$ while Qulqulluu variety seeds obtained from the same source sown at seed rate of 150 kg ha$^{-1}$ exhibited earliness to attain days to 50% heading (68.22 days). The earliness to days to heading might be due to the higher competition to resources as the result plants no longer to stay in vegetative stage. Earliness for days to heading had the advantage to escape terminal moisture stress and good character to cope up with the rainfall variability in growing area. This result is in agreement with the results reported by Tewodros *et al.* (2014) noted that days to heading showed significant difference among the genotypes. The mean for days to heading of tested genotypes ranged from 62 days (ETBW 5013) to 70 days (ETBW 5341).

*Days to 90% physiological maturity*

Days to 90% physiological maturity showed significant differences between varieties, among seed sources and seed rates. The interaction of variety and seed source also showed significant ($P<0.01$) variation on days to 90% physiological maturity. The data showed that Digalu variety grown from farmers saved seeds was late maturing which took the longest duration of (120.2 days) and Qulqulluu variety grown from seeds obtained from Haramaya University took the shortest duration (117.6 days). This might be due to the loss of water content in seeds obtained from Haramaya as it was observed from the rapid change of plants green color to yellowish at field evaluation. This result was in agreement with the results reported by Gary (1997) that physiological maturity occurs when the kernel has accumulated its highest content of dry matter, loose its water content, and changed color green to yellowish. The days to physiological maturity of wheat cultivars also varies due to inherent differences between cultivars (Shahzad *et al*., 2007). The seed rate of 150 kg ha$^{-1}$ exhibited early maturity which might be due to the increased plant population that increased intra-plant competition for nutrients and light which plants stay no longer for heading and maturity. This may have also contributed to the reduction in grain filling period, because heading and maturity at higher seed rate hastened than lower seed rate.

*3.2.2. Grain filling period*

The analysis of variance indicated that the main factor of variety and the interaction of variety, seed source and seed rate had significant (P<0.05) influence on grain filling period (table 2). Variety with the longest grain filling period might be due to the time needed for plants to uptake the nutrient in the soil. This result agreed with the results of Bachubhai (2011) and Pržulj and Momcilovic (2011) who noted that the length of grain growth is a process that is highly varietal dependent. Determination of the genetic base of variety helps breeders to develop new cultivars and give the chance for growers to select a most appropriate cultivar for a specific environment. In this study, Qulqulluu variety seed had sown which obtained from Kersa Local Seed Business Project, and seed rate increased from 125 to 150 kg ha$^{-1}$ decreased duration of grain filling period by 6.46%. This might be due to of genetic variation of the varieties in their phenology.

Table 2. Interaction effect of variety, seed source and seed rate on grain filling period (days), plant height (cm) and harvest index of bread wheat varieties

| Variety | Seed Source | Grain filling period | | | Plant height | | | Harvest index | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Seed rate (kg ha$^{-1}$) | | | Seed rate (kg ha$^{-1}$) | | | Seed rate (kg ha$^{-1}$) | | |
| | | 100 | 125 | 150 | 100 | 125 | 150 | 100 | 125 | 150 |
| Digalu | HU | 47.67$^{d}$ | 49.33$^{bcd}$ | 49.00$^{cd}$ | 103.5$^{f}$ | 107.0$^{de}$ | 107.4$^{d}$ | 43.57$^{ab}$ | 38.89$^{a-d}$ | 31.35$^{cde}$ |
| | LSB | 48.67$^{cd}$ | 48.33$^{cd}$ | 49.67$^{bcd}$ | 105.9$^{e}$ | 107.4$^{d}$ | 109.7$^{a}$ | 34.32$^{b-e}$ | 40.66$^{abc}$ | 42.87$^{ab}$ |
| | F | 49.00$^{cd}$ | 50.00$^{abc}$ | 48.67$^{cd}$ | 106.6$^{de}$ | 107.7$^{cd}$ | 109.5$^{ab}$ | 29.04$^{e}$ | 31.56$^{cde}$ | 34.08$^{b-e}$ |
| Qulqulluu | HU | 49.67$^{bcd}$ | 49.00$^{cd}$ | 49.33$^{bcd}$ | 86.9$^{h}$ | 96.2$^{g}$ | 97.0$^{g}$ | 42.17$^{ab}$ | 44.93$^{a}$ | 42.58$^{ab}$ |
| | LSB | 51.33$^{ab}$ | 51.67$^{a}$ | 48.33$^{cd}$ | 108.9$^{abc}$ | 109.3$^{ab}$ | 110.2$^{a}$ | 39.04$^{a-d}$ | 38.94$^{a-d}$ | 38.94$^{a-d}$ |
| | F | 49.67$^{bcd}$ | 50.00$^{abc}$ | 49.33$^{bcd}$ | 108.1$^{bcd}$ | 109.4$^{ab}$ | 109.4$^{ab}$ | 36.27$^{a-e}$ | 31.96$^{cde}$ | 30.77$^{de}$ |
| LSD (5%) | | | 1.76 | | | 1.33 | | | 8.07 | |
| CV (%) | | | 2.2 | | | 0.8 | | | 13 | |

Means with the same letter(s) in the same column and row of each trait are not significantly different at 5% probability level, LSD (5%) = least significant difference at 5% probability level, CV (%) = coefficient of variation in percent, HU = seed obtained from Haramaya University Wheat Research Program, LSB = seed obtained from Kersa Local Seed Business Project, F = seed samples obtained from farmers, kg ha$^{-1}$ = kilogram per hectare.

*3.2.3. Plant height*

The analysis of variance revealed that the three main factors (variety, seed source and seed rate) as well as all possible interaction of these factors significantly influenced plant height (table 2). Higher seed rate caused to changing plant height and stem thickness because of the lower light penetrating in to plants canopy bed and more inter specific competition to more absorption light. Rahim *et al.* (2012) also reported that the significant difference on plant densities of 450 and 300 plants m$^{2}$ with highest and lowest plant height, respectively, Other researchers also reported in wheat that the height of plants grown at the lowest seed rate was significantly lower than the height of plants grown at higher seed rates (Haile *et al*., 2013; Ghulam *et al.,* 2011). The current study result was also in agreement with the results of Abdul *et al.* (2014) who reported that tallness in wheat plants is mostly associated with the genetic makeup of the variety.

*3.2.4. Number of tillers*

The number of tillers were significantly affected (P<0.01) by main effect of variety, seed source and seed rate. Interaction effect of variety and seed source had highly significant effect on number of tillers per 1 m length. The highest tillers might be due to tillering capacity of the variety, highest kernel weight and adaptation to agro ecology and thus resulted in early germination and production of more number of tillers and productive tillers. This result was in agreement with the results reported by Zareian (2013) that difference in yield components especially the number of tillers per unit area in different seed sizes could be effective. Therefore, it is assumed that plants grown from small size seed had less number of tillers and fertile tillers than those grown from large size seed. In this study, seed rate had also significant effect on number of tillers. This result was in agreement with those of Veselinka *et al.* (2014) who reported that in crops with a lower density, a greater number of secondary tillers is created, which produce small grains with less weight and lower quality.

*3.2.5. Number of productive tillers*

The main effect of variety, seed source and seed rate and interaction effect of variety × seed source and variety × seed rate had significant effect on number of productive tillers per 1m length row. The higher population in 150 kg ha$^{-1}$ might have resulted in more intra-specific competition for limited resources, thus late growing tillers might be died because of high competition and resulted in low number of productive tillers would formed per 1 m length row.

This result was in agreement with the finding of Stoskopf (1985) who reported that better chance of early-formed tillers to survive and produce spikes; they develop before the onset of high temperatures that can elevate tiller mortality.

*3.2.6. Spike length*

The statistical analysis results revealed that spike length was significantly affected by seed rate. At the lower seed rate of 100 kg $ha^{-1}$, the spike length was higher compared to higher seed rate of 150 kg $ha^{-1}$. This might be due to more free space between plants at the lower seed rates and less intra-plant competition for available resources that resulted in higher spike length and shorter plant height. The current result was in agreement with the finding of Zewdie *et al*. (2014) who reported that shorter plant produce longer spike length and long plant produce shorter spike and higher biomass production. Similarly, Seleiman (2010) reported that the longest spikes were obtained from 250 and 300 grains per $m^2$ but without significant differences between both of them. However, the shortest spikes were recorded by using the highest seeding rate (400 grains per $m^2$).

*3.2.7. Number of kernels per spike*

Data recorded on number of kernels $spike^{-1}$ indicated that number of kernels $spike^{-1}$ of wheat varieties was significantly influenced by the main effect of variety, seed source and seed rate. It was also significantly ($P < 0.01$) affected by interaction of variety and seed source. Qulqulluu variety seed obtained from Kersa Local Seed Business Project gave maximum number of kernels $spike^{-1}$ (68.24), while seeds of Digalu variety obtained from farmers gave minimum kernels $spike^{-1}$ (53.31). This implies that Kersa Local Seed Business Project (LSB) seeds showed superiority over seed obtained from Haramaya University and farmer seeds. Similarly, maximum number of kernels $spike^{-1}$ (63.97) was obtained from the plot received seed rate of 100 kg $ha^{-1}$and minimum number of kernels $spike^{-1}$ (57.13) obtained from the plot that received seed rate of 150 kg $ha^{-1}$. The observed minimum grains $spike^{-1}$ in farmer saved seeds might be due to poor quality, less adaptability and management practices that lead to low number of kernels per spike. This result was in agreement with the results reported by Amir *et al*. (2007) that the minimum grains $spike^{-1}$ in farmer's wheat seed category might be due to aging of the seed, which resulted from poor quality seedling and poor management practices during its development. Significant difference was observed between plant densities of durum wheat cultivar interms of grains per spike. The highest and lowest grains per spike observed at lowest and highest plant densities, respectively (Rahim *et al.,* 2012).

*3.2.8. Thousand kernel weight*

The analysis of variance revealed that all the main effects (variety, seed rate and seed source) had significantly effect on thousand kernel weight (Table 3). The lowest kernels weight produced from highest seed rate might be due to thickening of population density which resulted completion of nearby plants in absorbing nutrients and moisture and that might leads to insufficient grain filling. In addition, the presence of higher spike number per rows leads to lower number of kernels per spike and small sized kernels because of inter plant competition to limited resources in the soil. Also other authors emphasized the influence of seed rate and plant density on 1000-kernel weight that as seed rate increased also number of spikes $m^{-2}$ increased, but 1000 kernel weight decreased (Hiltbrunner *et al.,* 2005; Dubis and Budzynski, 2006).

*3.2.9. Grain yield*

Analysis of variance showed that seed source and seed rate showed significant effect ($P < 0.01$) on grain yield. It was observed that using of Kersa Local Seed Business Project seed increases yield by about 23.14% and 11.57% over farmers saved seeds and seeds from Haramaya University, respectively. The increased seed rate results increased grain yield per plot and per hectare (Table 3). The maximum yield obtained from the use of higher seed rate might be due to high density of plants in rows and increased number of spikes per rows. The result was in conformity with result of Haile (2013) who reported that the lowest seed rate (100 kg $ha^{-1}$) resulted in a grain yield was significantly lower than the yields obtained at the other seeding rates (150 and 175 kg $ha^{-1}$). Seleiman (2010) also noted that grain yield $ha^{-1}$ was gradually and significantly increased as sowing density of bread wheat increased from 250 grains $m^{-2}$ up to 350 grains $m^{-2}$ and then the rate of increase remain constant with increasing sowing density up to 400 grains $m^{-2}$. The superiority of grain yield $ha^{-1}$ in dense sowing could be attributed to the higher number of spikes per unit area which reverse the effect of the increasing in the grain yield $spike^{-1}$ obtained as the sowing density was decreased.

*3.2.10. Biomass yield*

Data subjected to analysis of variance and the result indicated that all the three main effects (variety, seed source and seed rate) as well as interaction of variety and seed source showed significant effect on biomass yield. The maximum biomass yield obtained from LSB seeds of Qulqulluu variety might be due to the higher tillering capacity and higher plant height (Table 3). Higher tillers resulted in higher plants population and spikes per rows and plots leads to increased grain and biomass yield $ha^{-1}$. The result was in agreement with the finding of Zewdie *et al*. (2014) who reported a positive association between biomass yield and plant height, thus taller plants resulted higher biomass yield.

*3.2.11. Harvest index*

The analysis of variance showed that the seed source and the three way interaction (variety x seed source x seed rate) had significant ($P < 0.01$) and ($P < 0.05$) respectively influence on harvest index (Table 3 and 2 respectively). Harvest index had interrelationship with grain yield and above ground biomass yield that the highest harvest index was the result of greater grain yield. Lowest harvest index was mainly due to increased plant height and increased biomass yield rather than grain yield which lead to decrease of harvest index. The result also agreed with the result of Reynolds *et al.* (2009) who found that wheat cultivars have high harvest index most likely have high grain yield under field conditions.

Table 3. Effect of seed rate, seed source and variety on grain yield (t ha$^{-1}$), thousand kernel weight, biomass yield and harvest index of bread wheat grown in 2014 at Kersa

| Traits | GY (t ha$^{-1}$) | TKW (g) | BY (t ha$^{-1}$) | HI (%) |
|---|---|---|---|---|
| Seed rate (kg ha$^{-1}$) | | | | |
| 100 | 4.607$^{b}$ | 43.47$^{a}$ | 12.56$^{c}$ | 37.4 |
| 125 | 5.162$^{a}$ | 41.74$^{b}$ | 13.79$^{b}$ | 37.82 |
| 150 | 5.539$^{a}$ | 39.27$^{c}$ | 15.20$^{a}$ | 36.77 |
| LSD (5%) | 0.3873 | 1.674 | 0.838 | ns |
| Seed source | | | | |
| HU | 5.066$^{b}$ | 40.88$^{b}$ | 12.73$^{b}$ | 40.58$^{a}$ |
| LSB | 5.652$^{a}$ | 42.51$^{a}$ | 14.47$^{a}$ | 39.13$^{a}$ |
| F | 4.590$^{c}$ | 41.09$^{b}$ | 14.34$^{a}$ | 32.28$^{b}$ |
| LSD (5%) | 0.3873 | 1.183 | 0.3873 | 3.565 |
| Variety | | | | |
| Digalu | 5.12 | 40.97$^{b}$ | 14.28$^{a}$ | 36.26 |
| Qulqulluu | 5.09 | 42.01$^{a}$ | 13.42$^{b}$ | 38.4 |
| LSD (5%) | Ns | 0.966 | 0.684 | ns |
| CV (%) | 11.2 | 4.2 | 8.9 | 13 |

Means with the same letter(s) in the same column of each trait are not significantly different at 5% probability level, LSD (5%) = least significant difference at 5% probability level, CV (%) = coefficient of variation in percent, HU = seed obtained from Haramaya University Wheat Research Program (HU), LSB = Seed obtained from Kersa Local Seed Business Project, F = seed samples obtained from Farmer, GY = grain yield,TKW= thousand kernel weight, BY=biomass yield, HI= harvest index

## 4. Summary and Conclusions

Wheat (*Triticum aestivum* L.) is one of the most important world cereal crops and is a staple food for about one-third of the world's population. It is one of the cereal crops produced in eastern Ethiopia where its production and productivity is low due to the use of farm saved poor quality seeds, inappropriate seed rate and unavailability of adaptable varieties. This indicates that the need to conduct research and determine the optimal seed rate and use of quality seed of adaptable varieties in growing area as one of important agronomic managements to improve production and productivity of wheat. The study consisted of laboratory and field experiment of which laboratory experiment was conducted at Haramaya University Seed Science and Technology Laboratory and the field experiment was conducted at Kersa, eastern Ethiopia designed by randomized complete block design (RCBD) in 2 varieties (Digalu and Qulqulluu varieties) x 3 seed sources (Haramaya University, LSB and farmers as seed sources) x 3 seed rates (100, 125 and 150 kg ha$^{-1}$) factorial arrangements with three replications.

The two experiments results showed that the presence of significance difference among seeds of different sources for seed quality which consequently resulted significance difference in crop phenology, growth, yield and yield components of the two wheat varieties. These results suggested that the importance of using appropriate seed rate and quality seeds from reliable sources of improved varieties to increase yield of bread wheat in the study area. Qulqulluu variety, seed obtained from Kersa Local Seed Business Project and seed rate of 150 kg ha$^{-1}$ could be used to increase productivity of wheat. However, the experiments were conducted considering only two varieties, limited number of seed sources and seed rates and at one location which might be not represent all bread wheat growing areas of eastern Hararghe. Therefore, it is necessary to conduct the experiments considering more number of seed sources, seed rates and varieties at major wheat growing areas for more than one cropping seasons to make conclusive recommendation that can be applicable in eastern Hararghe.

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