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# Response of Bread Wheat (*Triticum aestivum* L.) Varieties to Seeding Rates at Kulumsa, South Eastern Ethiopia

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ABSTRACT

With the objective of determining the effect of seed rates on the growth parameters, yield components, yield and protein content of bread wheat varieties, a study was conducted at Kulumsa Agricultural Research Center from July to November 2012. Four varieties (Digalu, Danda'a, Kakaba and Shorima) and five seed rates (100, 125, 150, 175 and 200 kg ha$^{-1}$) and RCBD with three replications were used. The results showed that days to 50% heading, days to 90% physiological maturity, plant height, spike length, hectoliter weight and Harvest Index (HI) were affected highly significantly (p<0.01) by the main effects of variety and seed rate whereas, grain protein content was affected highly significantly (p<0.01) only by variety and above ground dry biomass yield was affected highly significantly (p<0.01) only by the main effect of the seed rate. Furthermore, the interaction effect of variety and seed rate significantly affected thousand kernels weight, number of effective tillers and number of kernels per spike and grain yield. The use of 150 kg ha$^{-1}$ seed rate for variety Shorima resulted in highest thousand kernels weight (39.48 g), number of kernels per spike (60.23) and grain yield (5339.3 kg ha$^{-1}$). From the result of this study, the use of 125 kg ha$^{-1}$ seed rate for variety Danda'a; 150 kg ha$^{-1}$ for varieties Shorima and Kakaba and 175 kg ha$^{-1}$ for variety Digalu were identified for good crop stand and finally the yield.

**Key words:** Bread wheat, seed rate, variety, grain protein content

## INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is the world's leading cereal grain where more than one-third of the population of the world uses as a staple food (Curtis, 2002). Wheat is one of the most important cereals cultivated in Ethiopia. It ranks fourth after tef (*Eragrostis tef*), maize (*Zea mays*) and sorghum (*Sorghum bicolor*) in area coverage, while fourth in total production after maize, sorghum and tef (CSA., 2012). Despite the large area under wheat, the national average yield of wheat in Ethiopia is about 2 t ha$^{-1}$ (CSA., 2012). This is definitely below the world's average which is about 3 t ha$^{-1}$ (Hawkesford *et al*., 2013). Cultivation of unimproved low yielding varieties, inadequate and erratic rainfall, poor agronomic practices, diseases and insect pests are among the principal limitations to wheat production in Ethiopia (Gorfu and Hiskias, 2000). Seed rate is one of the most important agronomic factors which need great emphasis for maximum yield of crops. High seed rate increases the competition among crops for common resource particularly water, nutrients and sunlight which resulting in low quality and low yield. If low seed rate is used yield will be less due to lesser number of plants per unit area (Hameed *et al*., 2002).

Concerning varietal differences, previous studies clearly showed that selecting varieties which are related to the specified density and use by farmers may be a feasible option for the improving wheat yields. Tiller number directly affects grain yield and it has great agronomic importance in wheat since it may partially or totally compensate the differences in plant number after crop establishment. The number of productive tillers is dependent on genotype (varieties) and environment and is strongly influenced by planting density (Fischer *et al.*, 1976). Tillering is increased with increasing light and nitrogen availability during the vegetative phase and depends greatly upon variety (Evans *et al*., 1975).

A number of bread wheat varieties differing in height, maturity and tillering capacity have been developed in Ethiopia. However, the recommended seed rate for all the varieties being used across the country is 150 kg $ha^{-1}$. Moreover, in the study area there is a trend by farmers to use higher seed rates as they have increased the rate of fertilizer use (personal observation). Thus, it is essential to determine the optimum seed rates for newly developed bread wheat varieties for the maximum yield. Therefore, this study was undertaken with the objective of determining the effect of seed rates on the growth parameters, yield components, yield and protein content of bread wheat varieties.

## MATERIALS AND METHODS

**Description of the study area:** The study was conducted at Kulumsa Agricultural Research Center (KARC) from July, 2012 to November, 2012 under rain fed conditions. The site is located at 8°00' N and 39°07' E at an elevation of 2210 m above sea level in Arsi Administrative Zone of Oromiya Regional State, 167 km South East of Addis Ababa. The agro-climatic condition of the area is wet and receives a uni-modial mean annual rainfall of 809.15 mm from March to September; however, the peak season is from July to August. The maximum and minimum mean temperature is 23.08 and 9.9°C, respectively (Esayas, 2003).

**Treatments and experimental design:** Twenty treatment combinations off our bread wheat varieties (Digalu, Danda’a, Kakaba and Shorima) and five seed rates (100, 125, 150, 175 and 200 kg $ha^{-1}$) were tested. A factorial arrangement in Randomized Complete Block Design (RCBD) with three replications was used. The gross plot size was 11 rows (3 m×2.2 m = 6.6 $m^2$) and the net plot consisted of 9 rows of 2.5 m length (2.5 m×1.8 m = 4.5 $m^2$). The spacing between plots and blocks were 0.8 and 2 m, respectively and the spacing between rows was 20 cm.

**Data collected and measurements**

**Days to 50% Heading (DH):** It was taken when the ears or panicles were fully visible on 50% of the plants from each plot by visual observation.

**Days to 90% physiological Maturity (DM):** It was taken when 90% of the plants in each plot reached maturity, i.e., when grains are difficult to divide by thumb nail.

**Plant height and spike length (PLH):** These were recorded when the crop reached maturity by measuring from 10 randomly selected plants from the net plot area.

**Number of Effective Tillers (NET):** It was recorded from the middle row of 0.5 m row length at physiological maturity.

**Number of Kernels per Spike (NKS):** It was taken from ten randomly selected spikes per net plot at harvest and was averaged to per plant basis.

**Thousand Kernels Weight (TKW):** The TKW was determined by weighing 1000 kernels sampled from the net plot using a sensitive balance and the seed was adjusted to 12.5% moisture content.

**Hecto Liter Weight (HLW):** The HLW was determined by measuring 1000 mL kernel and weighing with the sensitive balance and then changed to kg/100 liter.

**Above ground dry Bio Mass yield (ABM):** The ABM was recorded from nine center rows after sun drying to a constant weight.

**Grain Yields (GY):** The GY was recorded from nine center rows and then adjusted to 12.5% moisture level.

**Harvest Index (HI):** The HI was calculated as the ratio of grain yield to the above ground dry biomass yield expressed as a percentage.

$$HI = \frac{\text{Grain yield}}{\text{Above ground dry biomass}} \times 100$$

**Grain Protein Content (GPC):** The GPC was recorded after the grain was adjusted to 12.5% moisture content.

**Statistical data analysis:** All data collected were subjected to analysis of variance (ANOVA) procedure using SAS software. A significance difference between treatments was delineated by LSD (Least Significance Difference) test at 5% level of significance.

## RESULTS AND DISCUSSION

**Days to 50% heading:** Results showed that the main effect of variety and seeding rates had highly significant ($p<0.01$) effect on the number of days from sowing to 50% heading. However, the interaction effect of seed rate and variety did not show significant effect on days to 50% heading.

Variety Kakaba reached days to 50% heading earlier (61.27 days) while variety Digalu was late (77.87 days) as compared to the other varieties (Table 1). Furthermore, variety Digelu was late in days to 50% heading over variety Kakaba

Table 1: Main effect of variety and seeding rate on days to 50% heading, days to 90% physiological maturity, plant height and spike length

| Treatment | Days to 50% heading | Days to 90% maturity | Plant height (cm) | Spike length (cm) |
|---|---|---|---|---|
| **Variety** | | | | |
| Digalu | 77.87$^{a}$ | 126.00$^{a}$ | 109.56$^{a}$ | 6.47$^{d}$ |
| Danda'a | 76.07$^{b}$ | 124.60$^{b}$ | 106.87$^{b}$ | 8.55$^{c}$ |
| Kakaba | 61.27$^{d}$ | 109.00$^{d}$ | 94.16$^{d}$ | 9.40$^{b}$ |
| Shorima | 71.53$^{c}$ | 118.60$^{c}$ | 100.75$^{c}$ | 10.50$^{a}$ |
| LSD $_{(0.05)}$ | 1.20 | 0.85 | 2.10 | 0.39 |
| **Seed rate ( kg ha$^{-1}$)** | | | | |
| 100 | 70.50$^{b}$ | 118.75b | 104.27$^{a}$ | 8.86$^{ab}$ |
| 125 | 71.25$^{b}$ | 119.00b | 104.14$^{a}$ | 9.12$^{a}$ |
| 150 | 71.67$^{b}$ | 119.08$^{b}$ | 103.93$^{a}$ | 8.79$^{abc}$ |
| 175 | 71.83$^{ab}$ | 120.25$^{a}$ | 101.00$^{b}$ | 8.47$^{bc}$ |
| 200 | 73.17$^{a}$ | 120.83$^{a}$ | 100.78$^{b}$ | 8.40$^{c}$ |
| LSD $_{(0.05)}$ | 1.34 | 0.86 | 2.35 | 0.43 |

Means followed by the same letter case in a column are not significantly different from each other at 5% level of significance

by 27%. The difference in days to 50% heading among varieties could be attributed to the genetic factor. In line with this, varietal differences with respect to heading and flowering in rice crop were reported by Dingkuhn and Asch (1999).

Increasing seeding rates from 100-200 kg ha$^{-1}$ increased number of days from sowing to 50% heading from 70.5-73.17 (Table 1). It could be due to the reason that the use of low seed rate in wheat shortened the intervals between the growth phases by facilitating the physiological activities of crops due to the accessibility of ample resource. Similar result was obtained by Salem (1999) who found that increasing seeding rate from 60 up to 120 kg ha$^{-1}$ delayed the flowering and maturity of wheat crop. Likewise, Seleiman *et al.* (2010) reported that increasing seeding rates from 250-400 m$^{-2}$ grains caused a significant increase in the number of days from sowing to 50% heading in wheat. In contrast, Gafaar (2007) found that increasing sowing density from 200 up to 400 grains per meter square in wheat crop significantly decreased the number of days to 50% heading.

**Days to 90% physiological maturity:** The analysis of variance indicated that the main effect of variety and seeding rates had highly significant ($p<0.01$) effect on days to 90% physiological maturity while the interaction effect of seed rate and variety did not show significant effect on days to 90% physiological maturity.

Variety Kakaba followed by variety Shorima took significantly shorter time to mature as compared to varieties Danda’a and Digalu (Table 1). In conformity with the present result Geng (1984) reported that, differences in maturity can be caused by the combined effect of genetic and environmental factors during their growth and grain filling of the crops.

In line with days to 50% heading, the increment in seeding rate delayed physiological maturity of the bread wheat. Plots receiving the lowest seeding rate (100 kg ha$^{-1}$) reached physiological maturity 2 days earlier than the highest seed rate (200 kg ha$^{-1}$) (Table 1). This could be due to the reason that increasing in planting density enhances the competition and the crops will suffer from starvation due to the shortage of food prepared in the leaf by the process of photosynthesis which leads to late maturity of the crop. The result of this study was in line with that of Osman and Mohamed (1981) who reported that abundant supply of seed rates delay physiological maturity in wheat. The result was also in agreement with Seleiman *et al.* (2010) who reported that increasing seeding rates from 250-400 m$^{-2}$ grains prolong the number of days from sowing to maturity of wheat. In contrast, Melaku (2008) reported that increasing levels of seed rate promoted early physiological maturity of tef.

**Plant height (cm):** The result showed that plant height was highly significantly ($p<0.01$) affected by the main effect of variety and seed rate. However, the interaction effect of variety and seed rate was not significant. Variety Digalu had produced the tallest plant height of 109.56 cm, whereas, variety Kakaba produced the shortest plant height of 94.16 cm (Table 1). The difference in plant height of the varieties could be attributed to the difference in their genetic makeup. In agreement with this, Shahzad *et al*. (2007) reported that height of the crop is mainly controlled by the genetic makeup of a genotype and it can also be affected by the environmental factors. In case of seeding rates, plant height was reduced slightly at the highest seeding rates. The highest plant height (104.27 cm) was recorded from 100 kg ha$^{-1}$ seed rate however, statistically similar result was observed between 100, 125 and 150 kg ha$^{-1}$ seed rates while, the lowest plant height (101 and 100.78 cm) was recorded from seed rate of 175 and 200 kg ha$^{-1}$, respectively, which were statistically at par with each other (Table 1). This could be because of high competition among wheat plants for common resources.

The result obtained from this study was in agreement with Kanda and Nishizawa (1967) who revealed that dense planting promoted plant height to a certain level at the early stage of growth, while elongation was depressed at later period in rice crop. Similarly, Toaima *et al*. (2000) reported that, plant height was significantly decreased as seed rate increased in wheat crop. Baloch *et al*. (2002) also reported that the maximum plant height (103.3 cm) was observed with seed rate of 150 kg ha$^{-1}$ followed by 175 kg seed ha$^{-1}$ which produced plants of 93.2 cm in wheat. However, the result of this study was in contrast to that of Sulieman (2010) who reported that increase in the seeding rate resulted in a slight increment in the heights of the wheat.

**Spike length (cm):** As far as the seed rate and varieties are concerned, highly significant ($p<0.01$) difference was recorded for the spike length. But, the interaction between seed rate and varieties did not show significant effect. Variety Shorima produced the longest spike length of 10.5 cm while, variety Digalu produced the shortest spike length of 6.47 cm (Table 1). This result was in agreement with that of Otteson *et al*. (2007) who reported that individual genotypes responded differently to spike length for varying seeding rates in wheat. In the case of seed rate, the plot treated with 125 kg ha$^{-1}$ produced the longest spike length (9.12 cm) and seed rate of 200 kg ha$^{-1}$ produced the shortest spike length (8.4 cm). As seed rate increased from 125-200 kg ha$^{-1}$, the spike length was declined by 8.57%. This could be due to the availability of ample resources required by the wheat crop for growth and development in lower seeding rates. The result was in agreement with Jaama *et al*. (1998) who reported reduced spike length, fewer spikelet per spike and kernels per spikelet of triticale with increased seeding rate or plant density. Similarly, Mosalem *et al*. (2002) reported that increasing seeding rates decreased the number of spikelets per panicle, spike length, number and weight of grains per spike in wheat. Furthermore, Gafaar (2007) found that increasing sowing density from 200 up to 400 m$^{-2}$ grains significantly decreased spike length of bread wheat.

**Number of effective tillers per 0.5 m row length:** The analysis of variance indicated that the main effect of variety and seed rate had highly significant effect ($p<0.01$) on the number of effective tillers. Likewise, the interaction of variety and seed rates also revealed significant ($p<0.05$) effect on the number of effective tillers per 0.5 m row length.

The highest number of effective tillers per 0.5 m row length (69.33) was obtained at the combination of variety Danda'a and 200 kg ha$^{-1}$ seed rates while, the lowest number of effective tillers per 0.5 m row length (25.66) were obtained at combination of variety Digalu and 100 kg ha$^{-1}$ seed rate (Table 2). Such increment in number of effective tillers and spikes due to increasing sowing density could be attributed to increasing number of plants per plot and also tillering capacity. On the other hand, the lower number of tillers for variety Digelumight be attributed to the death of tillers due to low rainfall late in the growing season. This result was in agreement with Willey and Holliday (1971) where they indicated that high seeding rates generally increased number of spikes per square meter, although fewer and smaller kernels per spike can occur which results in little change in total grain yield. Kumar *et al*. (1991) and Ahmad *et al*. (1999) also confirmed the present result, where higher sowing rates increased the number of tillers m$^{-2}$ due to more plant population but number of tillers per seedling decreased with increased in seed rate. Geleta *et al*. (2002) and Gafaar (2007) also reported that, number of spikes m$^{-2}$ were increased with increasing seeding rate in wheat. Furthermore, varietal differences with respect to tillering capacity in rice crop were also reported by Wu *et al*. (1998) and Lafarge *et al*. (2004).

**Number of kernels per spike:** The result revealed that four varieties showed significant ($p<0.05$) difference with respect to the number of kernels per spike. While, the main effect of seed rate had highly significant ($p<0.01$) effect on number of kernels per spike. The interaction between the two factors was also significant. Variety Shorima combined with seed rate of 150 kg ha$^{-1}$ produced the highest number of kernels per spike (60.23) while, less number of kernels per spike (46.5) was recorded from the combination of variety Danda'a with seed rate of 200 kg ha$^{-1}$ (Table 3). Thus, variety shorima at seed rate of 150 kg ha$^{-1}$ exceed variety Danda'a at seed rate of 200 kg ha$^{-1}$ by about 29.52% in number of kernels per spike. This could be due to the effect of highest number of tillers (69.33) in variety Danda'a at seed rate of 200 kg ha$^{-1}$ than number of tillers (43.66) in variety Shorima at seed rate of 150 kg ha$^{-1}$. During grain filling period the food translocated from leaf could be less because of high competition under highest seed rate, as a result low grains would be produced. In general, seed rates up to 150 kg ha$^{-1}$ gave the higher number of kernels per spike for all the varieties while seed rates of 175 and 200 kg ha$^{-1}$ gave fewer kernels per spike. The result obtained from this study was in agreement with Hussain *et al*. (2001) who reported that the higher grain number obtained in the lowest seed rate can be attributed to more light penetration through plant canopy. Similar to this result, Baloch *et al*.

Table 2: Interaction effect of seeding rate and variety on the number of effective tillers per 0.5 m row length of bread wheat

| | Seed rate (kg ha$^{-1}$) | | | | |
|---|---|---|---|---|---|
| Variety | 100 | 125 | 150 | 175 | 200 |
| Digalu | 25.66$^{l}$ | 32.66$^{ijk}$ | 37.0$^{ghi}$ | 45.33$^{ef}$ | 49.33$^{ed}$ |
| Danda'a | 33.33$^{ijk}$ | 40.33$^{fgh}$ | 43.66$^{f}$ | 56.00$^{c}$ | 69.33$^{a}$ |
| Kakaba | 29.33$^{jkl}$ | 35.00$^{hi}$ | 41.33$^{fg}$ | 53.33$^{cd}$ | 56.33$^{bc}$ |
| Shorima | 28.33$^{kl}$ | 34.66$^{ij}$ | 43.66$^{f}$ | 53.0$^{cd}$ | 61.67$^{b}$ |
| LSD ($_{0.05}$) | | | 5.45 | | |
| CV (%) | | | 7.59 | | |

Means followed by the same letter case in a column and row are not significantly different from each other at 5% level of significance

Table 3: Interaction effect of seeding rate and variety on the number of kernels per spike of bread wheat

| | Seed rate (kg ha$^{-1}$) | | | | |
|---|---|---|---|---|---|
| Variety | 100 | 125 | 150 | 175 | 200 |
| Digalu | 54.53$^{b}$ | 53.63$^{bcd}$ | 52.97$^{b-e}$ | 51.57$^{b-g}$ | 51.40$^{b-g}$ |
| Danda'a | 52.10$^{b-f}$ | 53.50$^{bcd}$ | 49.03$^{e-h}$ | 49.97$^{d-h}$ | 46.50$^{h}$ |
| Kakaba | 52.63$^{b-e}$ | 54.43$^{bc}$ | 54.13$^{bcd}$ | 50.33$^{b-h}$ | 48.27$^{fgh}$ |
| Shorima | 54.50$^{b}$ | 54.03$^{bcd}$ | 60.23$^{a}$ | 50.10$^{c-h}$ | 47.47$^{gh}$ |
| LSD ($_{0.05}$) | | 4.28 | | | |
| CV (%) | | 4.97 | | | |

Means followed by the same letter case in a column and row are not significantly different from each other at 5% level of significance

(2002) reported that the increased plant spacing considerably resulted in vigorous plant growth and caused a significant increase in number of filled grain per panicle and thousand grain weights in rice crop. The result was also in agreement with Mehrvar and Asadi (2006) who reported that by increasing seed rate the number of grains per spike was reduced.

**Thousand Kernels Weight (TKW):** The result indicated that the main effects and their interaction affected TKW highly significantly (p<0.01). Maximum value of TKW (39.48 g) was recorded in the plot treated with seed rate of 150 kg ha$^{-1}$ for variety Shorima; whereas, the lowest TKW (27.78 g) was recorded from seed rate of 200 kg ha$^{-1}$ for variety Danda'a (Table 4). Accordingly, variety Shorima at seed rate of 150 kg ha$^{-1}$ exceeded variety Danda'a at seed rate of 200 kg ha$^{-1}$ by 42.1% in thousand kernels weight. This could be due to the late maturity of variety Danda'a which might have suffered from unfavorable environmental condition late in the growing season. In addition, high density caused to increasing number of spikes and as a result competition would increase and little photosynthates would be available to grain filling and finally thousand kernels weight would reduce due to high plant population.

Rafique *et al*. (1997) and Chaudhary *et al*. (2000) reported that, low seed rates significantly increased thousand kernels weight. Similarly, Jan *et al*. (2000) reported that, as the seeding rate was increased, the number of plants emerged per unit area also increased but thousand seed weight decreased in wheat crop. Khan *et al*. (2002) and Mehrvar and Asadi (2006) concluded that, by increasing seed rate the thousand grains weight was reduced in wheat.

**Hectoliter weight (HLW):** The result showed that a highly significant difference (p<0.01) on the HLW was observed among wheat varieties and seed rates. The highest HLW (75.2 kg hL$^{-1}$) was obtained from the variety Shorima followed by variety Digalu (74.42 kg hL$^{-1}$) while the lowest HLW (69.01 kg hL$^{-1}$) was recorded from variety Danda'a (Table 6). The result obtained in variety Danda'a was lower as compared with MoARD (2010) which reported the HLW of variety Danda'a to be 77 kg hL$^{-1}$. This could be due to effect of varying seed rates under this study. Similarly, Bordes *et al*. (2008) reported that some varieties have inherently higher HLW than others when grown under the same conditions. On the other hand, HLW was ranged from 69.01-75.12 kg hL$^{-1}$ for the varieties under this study which was in agreement with Atwell (2001) who reported that, hectoliter weight may range from about 57.9 kg hL$^{-1}$ for a poor wheat to about 82.4 kg hL$^{-1}$ for a sound wheat. Considering the main effect of seed rate, hectoliter weight was decreased as seed rate increased. Accordingly, the lowest hectoliter weight (72.15 kg hL$^{-1}$) was observed at application of 200 kg ha$^{-1}$ and the highest HLW (73.54 kg hL$^{-1}$) was observed at

Table 4: Interaction effect of seeding rate and variety on thousand kernels weight of bread wheat

| | Seed rate (kg ha$^{-1}$) | | | | |
|---|---|---|---|---|---|
| Variety | 100 | 125 | 150 | 175 | 200 |
| Digalu | 30.07$^{fgh}$ | 30.04$^{fgh}$ | 33.2$^{cde}$ | 30.3$^{efgh}$ | 29.73$^{fgh}$ |
| Danda'a | 30.74$^{efgh}$ | 30.73$^{efgh}$ | 31.14$^{efg}$ | 29.59$^{fgh}$ | 27.78$^{h}$ |
| Kakaba | 35.64$^{bcd}$ | 35.64$^{bcd}$ | 32.55$^{def}$ | 30.7$^{efgh}$ | 29.14$^{gh}$ |
| Shorima | 36.88$^{ab}$ | 36.2$^{bc}$ | 39.48$^{a}$ | 29.41$^{gh}$ | 28.54$^{gh}$ |
| LSD $_{(0.05)}$ | | 3.08 | | | |
| CV (%) | | 5.43 | | | |

Means followed by the same letter case in a column and row are not significantly different from each other at 5% level of significance

150 kg ha$^{-1}$. Similar result was obtained by Bavec *et al*. (2002) who reported that increasing seeding rate from 350-800 seeds per m$^2$ significantly decreased hectoliter weight in wheat. The present study was also in line with Tayyar (2010) who reported that hectoliter weights of the varieties were significantly influenced by genotype and also a direct correlation of grain yield and hectoliter weight was observed in wheat.

**Above ground dry biomass yield (kg ha$^{-1}$):** Analysis of variance showed that the main effect of seed rate had a highly significant effect on above ground dry biomass yield. On the other hand, although the difference was statistically not significant, variety Danda'a produced the highest above ground dry biomass yield (11244.4 kg ha$^{-1}$), while variety Digalu produced the lowest above ground dry biomass yield 10059.3 kg ha$^{-1}$ (Table 6). Similarly, interaction effect of variety and seed rate was not significant.

As far as the seed rate is concerned, maximum above ground dry biomass yield (11629.6 and 11166.7 kg ha$^{-1}$) were obtained by seed rate of 200 and 175 kg ha$^{-1}$ respectively, which were statistically at par with each other while, the lowest above ground dry biomass yield (9425.9 kg ha$^{-1}$) was produced by density of 100 kg ha$^{-1}$ (Table 6). The higher biomass yield with increased seed rate might be due to an increase in straw yield ha$^{-1}$ as seed rate increased. Similar results were obtained by El-Hebbasha (2001) and Ali *et al*. (2004) who found that biological yield was increased by increasing seeding rate in wheat. Moreover, Gafaar (2007) reported that the highest value of biological yield was obtained with increasing seed rate up to 400 grains m$^{-2}$ in wheat crop.

**Grain yield (kg ha$^{-1}$):** The result regarding grain yield showed that there were highly significant (p<0.01) differences in grain yield among wheat varieties and seed rates. Interaction among varieties and seed rates was also significant (p<0.05). The seed rate and wheat variety interaction showed that maximum grain yield (5339.3 kg ha$^{-1}$) was produced when seed rate was 150 kg ha$^{-1}$ for variety Shorima and the lowest grain yield (2851.9 and 2941.5 kg ha$^{-1}$) were recorded for variety Danda'a at 175 and 200 kg ha$^{-1}$, respectively. Among varieties, a visible dominance of variety Shorima was found over other varieties (Table 5). This could be due to its longest

Table 5: Interaction effect of seeding rate and variety on grain yield (kg ha$^{-1}$) of bread wheat

| Variety | Seed rate (kg ha$^{-1}$) 100 | 125 | 150 | 175 | 200 |
|---|---|---|---|---|---|
| Digalu | 2888.9$^{hi}$ | 3310.4$^{e-i}$ | 3338.5$^{e-i}$ | 3474.8$^{d-i}$ | 3148.9$^{ghi}$ |
| Danda'a | 3310.4$^{f-i}$ | 3561.5$^{c-h}$ | 3172.6$^{f-i}$ | 2851.9$^{i}$ | 2941.5$^{hi}$ |
| Kakaba | 3531.9$^{c-i}$ | 4162.2$^{bcd}$ | 4484.4$^{b}$ | 3862.2$^{b-f}$ | 3723.7$^{c-g}$ |
| Shorima | 3682.2$^{c-g}$ | 3900$^{b-e}$ | 5339.3$^{a}$ | 4229.6$^{bc}$ | 3983.7$^{b-e}$ |
| LSD $_{(0.05)}$ | | 697.8 | | | |
| CV (%) | | 11.26 | | | |

Means followed by the same letter case in a column and row are not significantly different from each other at 5% level of significance

Table 6: Main effect of variety and seeding rate on HLW (kg hL$^{-1}$), HI (%), BMY (kg ha$^{-1}$) and grain protein content (%)

| Treatments | HLW | ABM | HI | GPC |
|---|---|---|---|---|
| **Variety** | | | | |
| Digalu | 74.42$^{b}$ | 10059.3 | 32.3$^{b}$ | 10.1$^{c}$ |
| Danda'a | 69.01$^{d}$ | 11244.4 | 28.71$^{c}$ | 11.76$^{a}$ |
| Kakaba | 73.12$^{c}$ | 10488.9 | 38.1$^{a}$ | 10.53$^{bc}$ |
| Shorima | 75.2$^{a}$ | 10592.6 | 40.45$^{a}$ | 11.08$^{b}$ |
| LSD$_{(0.05)}$ | 0.72 | ns | 3.18 | 0.68 |
| **Seed rate(kg ha$^{-1}$)** | | | | |
| 100 | 73.36$^{a}$ | 9425.9$^{c}$ | 36.12$^{ab}$ | 11.08 |
| 125 | 73.16$^{ab}$ | 9870.4$^{bc}$ | 37.84$^{a}$ | 10.97 |
| 150 | 73.54$^{a}$ | 10888.9$^{ab}$ | 37.76$^{a}$ | 11.05 |
| 175 | 72.47$^{bc}$ | 11166.7$^{a}$ | 32.72$^{bc}$ | 10.29 |
| 200 | 72.15$^{c}$ | 11629.6$^{a}$ | 29.77$^{c}$ | 10.92 |
| LSD $_{(0.05)}$ | 0.8 | 1041.1 | 3.5 | ns |
| CV (%) | 1.33 | 11.88 | 12.34 | 8.46 |

HLW: Hectoliter weight, ABM: Above ground dry biomass yield, HI: Harvest index, GPC: Grain protein content. Means followed by the same letter case in a column are not significantly different from each other at 5% level of significance, ns: Not significant

spike length of 10.5 cm, which plays a vital role in wheat on the number of grains per spike and finally the yield (Shahzad *et al*., 2007). Except for variety Digalu, the result of this study was in agreement with Kumar *et al*. (2006) and Otteson *et al*. (2007) who reported that increasing sowing rates with optimum fertilizer application resulted in increased grain yield, NPK uptake, spike number, number of grains per spike and grain yield with increasing seed rates up to 150 kg ha$^{-1}$.

Furthermore, Baloch *et al*. (2002) reported that the use of 150 kg seed ha$^{-1}$ produced higher grain yield of 5103.3 kg ha$^{-1}$ than other seeding rates (100, 125, 175 and 200 kg ha$^{-1}$) used. Extra increase in seed rate did not improve grain yield because the dense wheat population creates keen competition between plants for nutrients, moisture etc, which leads to the decrease in grain yield. In other study, Sharshar and Said (2000) noted that wheat varieties significantly differed in grain yield and most of yield related traits.

Based on the result of this study, variety Danda'a required the low seed rate (125 kg ha $^{-1}$) for producing higher grain yield which may be due to its high tillering capacity while varieties Shorima and Kakaba gave maximum grain yield on seed rate of 150 kg ha$^{-1}$. On the other hand, variety Digalu produced best yield at 175 kg ha$^{-1}$ (Table 5). Moreover, 30.66% increase in grain yield when the seeding rate was increased from 100-175 kg ha$^{-1}$ in variety Digalu; 26.96 and 45% yield increase in case of variety Kakaba and shorima, respectively when the seed rate was increased from 100-150 kg ha$^{-1}$ and 21.07% yield reduction when the seed rate increased from 125-200 kg ha$^{-1}$ in variety Danda'a was recorded. These results indicated that each variety must not be sown at equal seed rate. The difference in the grain yield of wheat varieties might be due to the difference in their yield components like spike length, kernels per spike, no of effective tillers and the like.

**Harvest index (%):** Harvest Index (HI) was highly significantly (p<0.01) affected by seed rate and varieties but the interaction between the two factors was non-significant. The four varieties were significantly different from each other. Varieties Shorima and Kakaba gave the highest HI of 40.45 and 38.1%, respectively, as compared to the other varieties whereas variety Danda'a gave the lowest HI of 28.71% (Table 6). Significant varietal differences on harvest index in rice crop were also reported by Ottis and Talbert (2005). This could be due to high grain yield in variety Shorima and Kakaba as compared to others. Similarly, Donald and Hamblin (1976) reported that grain yield is proportional to HI and factors which make up grain yields such as grain weight and grains per spikelet have a relatively high effect on harvest index.

Seed rates of 125 and 150 kg ha$^{-1}$ produced the maximum HI of 37.84 and 37.76%, respectively, however, they are statistically similar while 200 kg ha$^{-1}$ gave the lowest harvest index of 29.77% (Table 6). This could be due to increasing in biological yield accompanied by an increase of grain yield in high seed rate. The result was in line with Zeng and Shannon (2000) who showed that at high density, carbohydrate supply was limited and this resulted in the reduction in harvest index. However, Mollah *et al*. (2009) reported that seed rate did not have significant effect on harvest index of wheat in bed planting condition.

**Grain protein content (%):** The data recorded have shown non-significant difference among different seeding rates. Similarly, the interaction between the two factors was also non-significant These results were supported by the findings of Khaliq *et al*. (1999) and Hussain *et al*. (2001) who reported that grain protein content did not affected by seeding rates in wheat. However, the difference among varieties was highly significant (p<0.01).

Variety Danda'a produced maximum grain protein content (11.76%) while the lowest protein content (10.1%) was produced by variety Digalu (Table 6). This variation in grain protein content of the varieties may be attributed to their variation in nutrient uptake and translocation capacities to the sink. Similar results were obtained by Stoddard and Marshall (1990) who reported that the protein content of wheat was mainly dependent upon varieties. Likewise, Gooding and Davis (1997) reported that, protein content is largely dependent on varieties but also clearly influenced by environment, especially N availability (soil N and rate and time of N application). Furthermore, Sadowska *et al*. (2001) concluded that, the grain quality and physical properties of the different wheat were influenced by the varieties. On the other hand, Sial *et al*. (2005) and Karimzadeh *et al*. (2006) found significant differences among different genotypes of wheat in grain protein content. Tayyar (2010) described that the wheat grain protein content is affected by some factors such as variety, location, crop year, temperature, rainfall and soil fertility etc. The result was in contrast with Gooding and Davis (1997) who reported that increment in grain weight was associated with increased protein content and therefore density of the grain. In general, grain protein content was ranged from 10.1-11.76% for the varieties under this study in agreement to this result, Bechere *et al*. (2002) reported that protein content of Ethiopian improved durum wheat cultivars released between 1966 and 1996 had ranged between 10.2-15.4%.

## CONCLUSION

In general, significant differences in grain yield and most of agronomic parameters of bread wheat were observed due to variety and seeding rates. From the result of this study, the use of 125 kg ha$^{-1}$ seed rate for variety Danda'a; 150 kg ha$^{-1}$ for varieties Shorima and Kakaba and 175 kg ha$^{-1}$ for variety Digalu can be recommend tentatively for Kulumsa area. Moreover, depending on the agronomic performance and yield of this study variety Shorima at 150 kg ha$^{-1}$ was advantageous. However, as this is one season and one location experiment, this experiment has to be repeated over locations and seasons with consideration of cost of production to reach at conclusive recommendation.

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