



Determination of Appropriate Seed Rate and Row Spacing of Bread Wheat for Highlands of Guji Zone

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ABSTRACT

Wheat is one of the major staple crops in Ethiopia in terms of both production and consumption. Even though it is such an important cereal crops in Ethiopia, it is giving low yield due to many production constraints such as lack of improved varieties, poor agronomic practice (inappropriate seeding rate and row spacing), diseases, weeds and low soil fertility in Ethiopia in general and in Guji zone in particular. Therefore, field experiment was conducted during the 2015-2017 main cropping season at Bore and Ana sora to assess the effect of seeding rate and row spacing on yield components and yield of bread wheat; and to determine appropriate seeding rates row spacing for bread wheat. The experiment was laid out RCBD in a factorial arrangement with three replications using a wheat variety known as 'Huluka' as a test crop. The treatments consisted of four levels of seeding rate (100, 125, 150 and 175 kg ha⁻¹) and four levels of row spacing (15, 20, 25 and 30 cm) consisting a total of 16 treatments. Analysis of the results revealed that all parameters were significantly ($P < 0.05$) affected by the interaction of the factors (seeding rate x row spacing) as well as the main effects except date to 50% heading and plant height which did not significantly ($P < 0.05$) affected. The highest grain yield (4239 kg/ha) were obtained from combination of 150 kg/ha seeding rate and 20cm row spacing. Therefore, use of 150 kg/ha and 20cm row spacing can be recommended for production of bread wheat for the study area (Bore and Ana Sora) and other areas with similar agro ecologies.

Keywords: Interaction, Interaction effect, Main effect, Nutrient,

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1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in terms of area and production in the world. It was grown on more than 216 million hectare (ha) of land with a total production of 651 million tonnes of grain in 2010 (FAOSTAT, 2012). In Ethiopia, wheat covered an area of 16.53 million ha with a total production of 30 million tonnes and yield average of 1781.9 kg/ha during 2010. Despite ranking third in area and fourth in production, it stood fourteenth in yield in Africa (FAOSTAT, 2012). Production of the crop is highly constrained, among others, by low soil fertility. Developing and using an improved variety alone is not enough to realize optimum production of the crop unless fertilizers are properly supplied (Tesfaye, 1987).

Besides regular nutrition of plants for achieving high yields and good quality, sowing time and planting density play an important role. Optimum plant densities vary greatly between areas, climatic conditions, soil, sowing time, and varieties. Since cultivars genetically differ for yield components, individual cultivars need to be tested at a wide range of seeding rates to determine their optimum seeding rate (Wiersma, 2002). Management practices play an important role in determining yield and end-use quality of wheat.

Numerous studies have documented how seeding rate, planting date, row spacing, and seeding depth affect yield and yield components of wheat (Wajid *et al.*, 2004; Guberac *et al.*, 2005; Schillinger, 2005; Kristó *et al.*, 2007; Maric *et al.*, 2008; Otteson *et al.*, 2008; Valério *et al.*, 2009). Seeding rate affected virtually all of the agronomic variables. (J. T. O'Donovan¹, T. K. Turkington¹, M. J. Edney², 2011). Using appropriate seeding rate which fits specific wheat genotypes is necessary to optimize grain yield and enhance grain protein content of the crop (Haile D, 2013).

Narrow row spacing causes higher leaf photosynthesis and suppresses weeds growth compared with wider row spacing. Narrow row

spacing also produces high leaf area index (LAI), which results in more interception of photo synthetically active radiation (PAR) and dry matter accumulation (DMA) (Tollenaar, M. and A. Auguiler, 1992).

Southern Oromia in general, Guji zone in particular is one of the major wheat growing area; especially highland parts. Even though it is such dominant crop in the zone, the yield obtaining is very low (24.17Qt/ha) which is less than national and African production. These are due to poor agronomic practices such as row spacing, seeding rate, sowing date, weeding and lack of improved variriy (personal observation). In addition to this, there were no research conducted concerning seeding rate and appropriate row spacing. As a result of this fact, the farmers rely on traditional practices (broad casting) and un appropriate seeding rate. Therefore, there is a need to study the effect of different seeding rates & row spacing on the yield and yield components of bread wheat and determine optimum seeding rate and row spacing for production and productivity of bread wheat at Bore and Ana Sora.

Objectives:

- To Determine Appropriate Seeding Rate and row spacing of Bread Wheat for the Area
- To Identify the Best Combination of Row Spacing and Seeding Rate of Bread Wheat for the study Area

2. MATERIELS AND METHODS

The experiment was conducted at Bore and Anna Sora districts using Huluka variety as planting material. The treatments consisted of factorial combination of four levels of row-spacing (15, 20, 25, 30 cm) and four levels of seeding rate (100,125, 150, 175 kg ha⁻¹). The experiment was laid out in a randomized complete block design (RCBD) with three replications in factorial arrangement of 4 x 4 making a total of 16 treatments. The gross size of each plot was 2.4 m x 2.5 m (6 m²) consisting of 16, 12, 10 and 8 rows for 15,20,25 and 30cm row spacing respectively and the distance

between adjacent plots and blocks were 0.5 m and 1 m apart, respectively.

The outermost one row on both sides of each plots were considered as border plants and were not used for data collection to avoid border effects. Fertilizer used was 46/41 P₂O₅/N per hectare and Nitrogen fertilizer was split, ½ at planting and ½ at peak tillering stage.

2.1. Data Collection and Measurement

2.1.1. Crop phenology and growth parameters

Days to 50% heading (DTH): days to spike heading was determined as the number of days taken from the date of sowing to the date of 50% heading of the plants from each plot by visual observation.

Days to 90% physiological maturity (DTM): days to physiological maturity was determined as the number of days from sowing to the date when 90% of the peduncle turned to yellow straw color. It was recorded when no green color remained on glumes and peduncles of the plants, *i.e.* when grains are difficult to break with thumb nail.

Plant height (cm): plant height was measured from the soil surface to the tip of the spike (awns excluded) of 10 randomly tagged plants from the net plot area at physiological maturity.

Spike length (cm): It was measured from the bottom of the spike to the tip of the spike excluding the awns from 10 randomly tagged spikes from the net plot.

2.1.2. Yield components and yield

Number of tillers per plant: number of tillers per plant was determined from 10 tagged plants per net plot at physiological maturity by counting the number of tillers after removing soils surrounded the tillers.

Number of productive tillers: number of productive tillers was determined at maturity by counting all spikes bearing tillers from two rows of 0.5 m length per plot at physiological maturity.

Number of spikelet per spike: the mean number of spikelet per spike was computed as an average of 10 randomly tagged spikes from the net plot area.

Thousand kernels weight (g): thousand kernels weight was determined based on the weight of 1000 kernels sampled from the grain yield of each net plot by counting using electronic seed counter and weighed with electronic sensitive balance. Then the weight was adjusted to 12.5% moisture content.

Grain yield (kg ha⁻¹): grain yield was taken by harvesting and threshing the seed yield from net plot area. The yield was adjusted to 12.5% moisture content as:

$$\text{Adjusted grain yield} = \frac{(100 - \text{MC}) \times \text{unadjusted grain yield}}{100 - 12.5}$$

Where MC- is the moisture content of bread wheat seeds at the time of measurement and 12.5 is the standard moisture content of bread wheat in percent. Finally, yield per plot was converted to per hectare basis and the yield was reported in kg ha⁻¹.

3. Statistical Data Analysis

All data collected were subjected to analysis of variance (ANOVA) procedure using GenStat (18th edition) software (GenStat, 2012). Comparisons among treatment means with

significant difference for measured characters were done by using Fisher's protected Least Significant Difference (LSD) test at 5% level of significance.

4. RESULTS AND DISCUSSION

4.1. Crop phenology and growth parameters

4.1.1. Days to 50% heading

The analysis of variance revealed that the interaction of the factors (spacing x seeding) and main effects did not significantly ($P < 0.05$) effect

days to 50% heading of wheat (Table 1). Lack of significance might be heading of the crop is mainly controlled by the genetic makeup of a genotype. This result is in line with the findings of Jehan *et al* (2007) who reported non significant heading on row spacing as well as interaction of row spacing and different varieties.

4.1.2. Days to 90% physiological maturity

The analysis of variance revealed that the interaction of the factors (spacing x seeding) and the main effects were highly significantly ($P < 0.01$) affected days to 90% physiological maturity of wheat.

The results showed that increasing row spacing across seeding rate increased days to physiological maturity of wheat. The longest

days to physiological maturity (147.1 days) was recorded at the combination of 150kg/ha seeding rate and 30cm spacing which is statistically at par with 100kg seeding rate and 25cm spacing whereas the shortest days to physiological maturity (145.2 days) was obtained from 125kg/ha and 15cm spacing. The decrease in days to maturity of wheat at the lowest row spacing might be due to high competition at lower spacing resulting non vegetative growth.

In line with this result, Jehan *et al* (2007) reported significant effect of row spacing on date to maturity. They reported delayed date to maturity at spacing of 60cm.

Table 1. Interaction effect of seeding rate and row spacing on days to 50% heading and 90% physiological maturity

Row spacing (cm)	DTH				DTM			
	Seeding rate(kg)				Seeding rate(kg)			
	100	125	150	175	100	125	150	175
15	75.39	75.83	75.33	75.56	146 ^{cde}	145.2 ^h	146.4 ^b	145.4 ^{gh}
20	75.94	75.72	75.11	75.5	145.7 ^{efg}	146.8 ^a	145.6 ^{fgh}	146.3 ^{bc}
25	75.61	75.61	75.61	75.28	147.1 ^a	146 ^{cde}	146.1 ^{bcd}	145.6 ^{fgh}
30	75.89	75.17	75.39	75.61	145.4 ^{gh}	145.7 ^{efg}	147.1 ^a	145.8 ^{def}
Mean	75.71	75.58	75.36	75.49	146.06	145.93	146.27	145.78
LSD(0.05)	NS				0.34			
CV (%)	0.5				0.1			

Means with the same letter(s) in the columns and rows are not significantly different at 5% level of significance, CV (%) = Coefficient of variation, LSD = Least Significant Difference at 5% level

4.1.3. Plant height

The analysis of variance revealed that the interaction of the factors (spacing x seeding) did not significantly ($P < 0.05$) affect plant height of wheat as well as the main effects. This might be due to plant height is mainly controlled by genetic make (Shahzad *et al*, 2007). Jehan *et al* (2007) also reported non-significant effect of row spacing for plant height.

4.1.4. Spike length

The analysis of variance revealed highly significant ($P < 0.01$) effect of the factors (spacing x seeding) as well as the main effect of seeding rate whereas the main effect of spacing significantly ($P < 0.05$) influence this parameter.

The longest spikes (8.81 cm) were obtained at 150kg/ha seeding rate and 20cm row spacing whereas the shortest spikes (6.37cm) were produced at 175kg/ha and 15cm row spacing

(Table 2). This result disagree with the finding of Rahel and Fikadu (2016) who reported no significant effect of seeding rate and row spacing on spike length.

4.2. Yield Component and Yield

4.2.1. Number of tillers per plant

The interaction effect of the two factors (spacing x seeding) and the main effect of spacing were significant ($P < 0.05$) on tiller number produced per plant whereas the main effect seeding rate did not.

The maximum number of tillers per plant (4.7) was produced by plants treated with the combined application of the second seeding rate

(125kg/ha) and row spacing (20cm whereas the minimum number of tillers per plant (3.36) was produced at the highest seeding rate rates (175 kg/ha and the lowest row spacing (15cm). This might be due to the fact that plants such as wheat can increase root growth to enhance nutrient uptake and tiller, especially during early growth stage as seeding rate decrease and row spacing increase. In line with this result, Iqbal *et al.* (2010) reported significant effect of row spacing on the number of tiller per plant and the number of fertile tillers. But the result did not agree with that of Rahel and Fikadu (2016) who reported no effect/interaction of seeding rate and row spacing on number of tiller of bread wheat.

Table 2. Interaction effect of Row spacing, seeding rate, location and year on plant height of bread wheat

Row spacing (cm)	Spike length				Plant height			
	Seeding rate(kg)				Seeding rate(kg)			
	100	125	150	175	100	125	150	175
15	8.44 ^{ab}	8.70 ^{ab}	8.42 ^{ab}	6.37 ^c	85.81	86.71	89.4	86.43
20	8.49 ^{ab}	8.50 ^{ab}	8.81 ^a	8.19 ^b	86.25	84.81	88.59	86.62
25	8.58 ^{ab}	8.48 ^{ab}	8.54 ^{ab}	8.35 ^{ab}	87.22	86.94	88.32	89.39
30	8.617 ^{ab}	8.63 ^{ab}	8.61 ^{ab}	8.66 ^{ab}	86.51	85.81	88.81	87.55
Mean	8.53	8.58	8.59	7.89	86.45	86.07	88.78	87.49
LSD(0.05)	0.55				NS			
CV (%)	3.9				2.0			

Table 3. Interaction effect of spacing x seeding on number of tillers per plant of bread wheat

Row spacing (cm)	Number of fertile tiller/plant				Number of total tiller/plant			
	Seeding rate(kg)				Seeding rate(kg)			
	100	125	150	175	100	125	150	175
15	4.06 ab	3.83 ab	3.49 b	2.42 c	4.531 a	4.44 ab	3.93 b	3.36 c
20	4.08 ab	3.66 ab	3.98 ab	4.15 ab	4.28 ab	4.70 a	4.53 a	4.61 a
25	3.94 ab	4.17 ab	4.15 ab	4.22 a	4.53 a	4.52 a	4.55a	4.63 a
30	4.08 ab	3.89ab	4.28 a	3.98 ab	4.47 ab	4.33 ab	4.66 a	4.45 ab
Mean	4.04	3.89	3.98	3.69	4.46	4.51	4.42	4.26
LSD(0.05)	0.72				0.54			
CV (%)	11.1				7.3			

Means with the same letter(s) in the columns and rows are not significantly different at 5% level of significance, CV (%) = Coefficient of variation, LSD= Least Significant Difference at 5% level

4.2.2. Number of productive tillers

The interaction effect of the factors (spacing x seeding) and main effect of spacing significantly ($P < 0.05$) influenced the number of productive tillers of bread wheat except seeding rate.

Thus, significantly highest number of productive tillers (4.28) was produced at the third levels of the two factors whereas the lowest (2.42) was recorded at the highest seeding rate and the lowest row spacing (Table 3).

The increase in the number of productive tiller produced in response to the increased row spacing and decreased seeding rate might be due to less inter plant competition for nutrients, space and other light by the plant even though there were no consistency. This result agrees with the findings of Iqbal *et al* (2016) who reported that different number of productive tiller under different seeding rate. The current result was not agreed with those of Rahel and Fikadu (2016) who reported no interaction of seeding rate and row spacing.

4.2.3. Thousand Kernels weight

The interaction effect of spacing and seeding rate, as well as the main effects significantly ($P < 0.05$) influenced thousand kernels weight of wheat. The highest thousand kernels weight (44.82 g) was recorded at combination of 125kg/ha seeding rate and 30cm row spacing. On the other hand, the minimum thousand kernel weight (34.75 g) was observed at combination of 175kg/ha and 15cm row spacing. Thousand kernels weight obtained from the highest seeding rate and the lowest row spacing was significantly lower than thousand seed weight from the lowest seeding rate and highest row spacing. This might be due to the increment of seed size at higher spacing and lower seeding rate due to less competition. The current result was agreed with those of Jehan *et al* (2007) who reported significant effect of row spacing on thousand seed weight. But result was not agreed with those of Rahel and Fikadu (2016) who reported no significant effect of seeding rate and row spacing on thousand seed weight.

Table 4. Interaction effect of row Spacing and seeding rate on thousand kernels weight of bread wheat.

	Thousands kernels weight*			
Row spacing(cm)	Seeding rate(kg)			
	100	125	150	175
15	41.53 ^{abc}	44.62 ^a	41.99 ^{abc}	34.75 ^d
20	44.79 ^a	42.42 ^{abc}	44.2 ^{ab}	40.89 ^{abc}
25	42.56 ^{abc}	41.45 ^{abc}	39.5 ^c	40.04 ^{bc}
30	42.72 ^{abc}	44.82 ^a	41.57 ^{abc}	42.88 ^{abc}
Mean	42.9	43.3275	41.815	39.64
LSD(0.05)	4.56			
CV (%)	6.5			

4.2.4. Number of spikelet per spike

The interaction effect of the two factor (spacing x seeding rate) and seeding rate significantly ($P < 0.05$) influenced number of spikelet per spike whereas the main effect of spacing highly significantly ($P < 0.01$) affect number of spikelet per spike.

The maximum numbers of spikelet per spike (16.65) was produced at he combination of 100kg/ha seeding rate and 30cm row spacing which was statically at par with all other combination except the minimum spacing and maximum seeding rate. But the minimum number of spikelet per spike (14.33) was produced at 175kg/ha seeding rate and 15cm row spacing of the two factors a. The lowest numbers of spikelet per spike at the narrow spacing might be due to increment of competition for light, nutrient and space at lower spacing. This result was not agreed with those of Rahel and Fikadu (2016) who reported no interaction of seeding rate and row spacing.

4.2.6. Grain yield

The interaction effect of the two factors (spacing x seeding rate) and their main effects significantly ($P < 0.05$) influenced grain yield of bread wheat. Increasing row spacing across the levels of seeding rate significantly increased grain yield. Thus, the highest grain yield (4239

kg ha⁻¹) was obtained at combined rates of 150 kg ha⁻¹ and 20cm row spacing whereas the lowest grain yield (2737 kg ha⁻¹) was recorded at the combinations of 175kg/ha seeding rate and 15cm row spacing (Table 5). The highest grain yield at the medium row spacing and seeding rate might have resulted from improved root growth and increased uptake of nutrients and better tiller and growth favored due to less competition which enhances yield components and yield by decreasing inter plant competition for light, space and light

In line with the result of this study Iqbal *et al* (2010) reported maximum grain yield (4.120t/ha and 3.922t/ha) at 150kg/ha seeding rate and 22.5cm row spacing respectively for wheat. Similarly, Rahel and Fikadu (2016) also reported that increasing seeding rate increase grain yield of bread wheat where the application of 150 kg ha⁻¹ gave more grain yield than others. But they reported non interaction of seeding rate and row spacing. Similarly to the above, Hameed *et al*. (2003) found that increasing seeding rate increased grain yield of bread wheat. Nazir *et al* (200) also found maximum grain yield at 150kg/ha seeding rate.

Table 5. Interaction effect of row Spacing and seeding rate on Grain yield and number of spikelet per spike of bread wheat.

Row spacing (cm)	Grain yield(kg/ha)				Number of spikelet per spike			
	Seeding rate(kg)				Seeding rate(kg)			
	100	125	150	175	100	125	150	175
15	3577 ^{b-f}	3075 ^{fg}	3605 ^{b-e}	2737 ^g	16.08 ^a	16.5 ^a	16.02 ^a	14.3 ^b
20	3551 ^{b-f}	3603 ^{b-e}	4239 ^a	3356 ^{c-f}	16.17 ^a	16.36 ^a	16.49 ^a	16.36 ^a
25	3107 ^{efg}	3464 ^{c-f}	3818 ^{abc}	3624 ^{bcd}	16.59 ^a	16.09 ^a	16.51 ^a	16.58 ^a
30	3267 ^{def}	3547 ^{b-f}	4043 ^{ab}	3083 ^{fg}	16.65 ^a	16.58 ^a	16.57 ^a	16.48 ^a
Mean	3375.49	3422.2	3926.24	3200.09	16.37	16.3825	16.40	15.94
LSD(0.05)	505.24				0.78			
CV (%)	8.7				2.9			

5. SUMMARY AND CONCLUSIONS

Wheat is one of the major staple crops in Ethiopia in terms of both production and consumption. Even though it is such an important cereal crops in Ethiopia, it is giving low yield due to many production constraints such as minimum use of improved varieties, diseases, agronomic practice (seeding rate and row spacing), weeds and low soil fertility in Ethiopia in general and in Guji zone in particular. Therefore, field experiment was conducted during the 2015-2017 main cropping season at Bore and Ana sora to assess the effect of seeding rate and row spacing on yield components and yield of bread wheat; and to determine appropriate seeding rates row spacing for bread wheat.

The experiment was laid out as a Randomized Complete Block Design (RCBD) in a factorial arrangement with three replications using a wheat variety known as 'Huluka' as a test crop. The treatments consisted of four levels of seeding rate (100, 125, 150 and 175 kg ha⁻¹) and four levels of row spacing (15, 20, 25 and 30 cm) consisting a total of 16 treatments.

Analysis of the results revealed that all parameters were significantly ($P < 0.05$) affected by the interaction of the factors (seeding rate x row spacing) as well as the main effects except date to 50% heading and plant height which did not significantly ($P < 0.05$) affected. The highest grain yield (4239 kg/ha), were obtained from combination of 150 kg/ha seeding rate and 20cm row spacing. Therefore, use of 150 kg/ha and 20cm row spacing can be recommended for production of bread wheat for the study area and other areas with similar agro ecologies.

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