Journal of Tropical Crop Science Vol. 9 No. 2, June 2022
www.j-tropical-crops.com

Maximizing Seed Quality and Seed Yield of Bread Wheat (*Tritium aestivum* L.) Through Agronomic Management in Amhara Region, Northwestern Ethiopia

Bitwoded Derebe*[A], Alemayehu Assefa[A], Alemu Abate[B] and Tilaye Anbes[A]

[A] Amhara Regional Agricultural Research Institute, P. O. Box. 527, Bahir Dar, Ethiopia.
[B] Bahir-Dar university, Zenzelma Campus P. O. Box. 5501, Bahir Dar, Ethiopia.

*Corresponding author; e-mail: bitwoded12@gmail.com

Abstract

A study was conducted to determine the optimum seed rate and row spacing on Kekeba bread wheat seed yield and quality performance at Adet and Wonberema, Ethiopia. The study consists of field experiments that were conducted at Adet Research Center and Wonberema farmer's field during the 2018 and 2019 cropping seasons, and laboratory experiments at the Seed Science Laboratory at Adet Research Centre. A factorial combination of eight seed rates (75, 100,125, 150, 175, 200, 225, and 250 kg.ha^{-1}) and two-row spacing (20 cm and 30 cm) was arranged in a randomized complete block design with three replications, and laboratory experiment in a complete randomized design with four replications. The results showed that the interaction effect of seed rate and row spacing was significantly ($P<0.05$) affected seed yield but had non-significant ($P>0.05$) on physical quality, physiological, and seedling vigor. Seed rate and row spacing had a significant ($P<0.05$) effect on standard germination, speed of germination, vigor index-I, and vigor index-II, but a pure seed was not significantly affected by the main effects and interaction. Based on the economic analysis at Adet, the maximum seed yield (4.4 t.ha^{-1}) was obtained from a seed rate of 125 kg.ha^{-1} with 20 cm row spacing, and at Wonberema the maximum seed yield (3.26 or 3.17 t.ha^{-1}) were obtained from a seed rate of 150 or 125 kg.ha^{-1} with 30 cm row spacing. Therefore, a seed rate of 125 kg.ha^{-1} with 20 cm row spacing was recommended at Adet, and at Wonberema seed rates of 150 and 125 kg.ha^{-1} with 30 cm row spacing was recommended for high seed yield and quality seed production as the 1st and the 2nd options, respectively.

Keywords: physical purity; seedling vigor index; standard germination

Introduction

Ethiopia is the second-largest producer of wheat in Sub-Saharan Africa, following South Africa (White et al., 2001). However, the productivity of wheat in Ethiopia is much lower than the yields of other wheat-producing countries of the world (White et al., 2001). Nationally, more than 4 million private peasant holders have grown wheat on about 1.78 million ha of land and 53.15 million quintals of production in 2019/20 main cropping season (CSA, 2019/20). Bread wheat is one of the major strategic food security crops in Ethiopia. Seed is the most important agricultural input, and it is the basic unit for distribution and maintenance of plant population (Mugonozza, 2001). High-quality seed is a critical input in crop production. Seed quality is a total of many aspects, including genetic, physical, physiological, and health quality (Tripp et al., 1997). It is essential for the successful establishment, uniform growth, and maximum productivity of crops and forage species. This highlights the need for effective seed quality assurance as an integral part of any seed supply system. As consumers become more discerning, they increasingly recognize the relationship between high-quality seed and crop performance; thereby increasing demand for better quality seed. It then becomes more important to ensure that seed producers have the necessary technological skills to produce good quality seed, thereby complementing improvements made through new cultivars and improved agronomic practices (Beavis and Harty, 1999). The poor genetic potential of varieties and the use of inadequate seed quality are some of the reasons for the low productivity of the crop. Wheat plant population density is an important agronomic trait that can influence the yield and seed quality of the crop (Zhang et al., 2016; Zecevic et al., 2014). In other words, optimum seeding rate and suitable cultivars play an important role in achieving the potential yield of bread wheat (Nizamani et al., 2014). Seeding rates above or below the optimum may reduce the seed yield and quality significantly (Peter et al., 1988); Karta et al. (2015) reported that as the seed rate increased seed quality and multiplication ratio would reduce; these might be due to high competition among plants as a result little assimilates would be available to grains. High-quality seed enhances the productivity and production of a given crop, and it has been attained through the use of recommended packages and other seed crop management practices, bread wheat seed-producing farmers in North-Western Ethiopia do not use the seed rate recommended by researchers as they usually use higher seed rate and high row spacing (Sewagegn Tariku et al., 2018). Besides the positive impact on seed quality, lower seed rates are important to enhance fast-track variety release by accelerating early generation seed supply through increased seed multiplication ratio (Gastel et al., 2002). Reports are available on the effects of seed rate on grain yield of wheat under the Ethiopian context (Assefa et al., 2015), thus, the use of a high seed rate and inadequate row spacing affect the quality of the seed. The main limitation of the germination test is its inability to detect quality differences among seed samples at high germination percentages and failure to predict field emergence under adverse field conditions for example in wheat (Vieira et al., 1999). The present experiment was conducted to investigate the effect of seed rate and row spacing on seed yield and quality of bread wheat.

Materials and Methods

Description of The Study Area

The field experiment was conducted on Adet Research Center experimental site and farmers field at Wonberema district during the main cropping season of 2018 and 2019. The laboratory experiment also was conducted on the Adet Seed Science and Technology laboratory. Wonberema district is located at 10°20'0''-10°40'0'' N and 36°35'0''-37°0'0'' E with an altitude of 2600 meter above the sea level (masl). The minimum and maximum temperatures were 17°C and 25°C, respectively. Adet district is located between 11°5'0''11°25'0'' N and 37°20'0''37°40'0'' E with an altitude of 2240 masl. The minimum and maximum temperatures were 11.28°C and 25.5 °C, respectively.

Treatments and Experimental Design

The treatments consisted of eight seeding rates (75,100,125,150,175, 200, 225, and 250 kg.ha^{-1}) and two-row spacing (20 cm and 30 cm). The experiment was laid out as a randomized complete block design in a factorial arrangement and replicated three times per treatment. Each plot had a gross plot size of 3 m in width and 2 m in length. The net plot size was 4.8 m^2 and 5.2 m^2 for 30 cm and 20 cm row spacing, respectively. The spacing between blocks and plots were 1 m and 0.5 m, respectively. The treatments were laid out in a complete randomized design for the laboratory seed quality parameter tests. The treatments were assigned randomly and each treatment was replicated four times. The plant material for this study was "Kekeba" bread wheat variety.

Agronomic Practices and Treatment Applications

The experimental field was prepared using oxen power and plowed four times, leveled manually and seed plots were prepared according to farmer's cultural practice and planting was done by hand on July 20, 2018, and June 28, 2018, at Wonberema and Adet, respectively. The recommended fertilizer rate of 138 kg N.ha^{-1} and 92 kg N.ha^{-1} was used at Wonberema, and Adet, respectively (Minale et al., 2006). Phosphorus at 38 kg P_2O_5 per ha was used in both districts. All phosphorus was applied at planting whereas nitrogen was applied in split doses, i.e., 1/3rd at sowing and the remaining (2/3rd) at tillering. The fertilizers used were urea and blended NPS (19 kg N-38 kg P_2O_5-7 kg S). One hoeing was done three weeks after sowing and hand weeding was carried out to keep the plots free from weeds and to provide better aeration. The next two hand weeding activities were operated at mid-tillering and booting stages. Harvesting was done manually by sickle at physiological maturity.

Laboratory Data Collection

One kg samples of harvested seed were subjected to seed quality analysis. Sampling was done according to Ethiopian Standard Agency sampling specification number ES 471/2000. Accordingly, composite samples were taken on a harvested basis and submitted to the Adet Agricultural Research Center seed laboratory. Samples were divided into working samples at the seed lab level for data collection of physical, physiological purity, and seedling vigor. Purity and germination tests were considered according to ES 414/2012 and all tests were performed according to procedures described by (ISTA, 2003). Data on the following quality parameters were collected in laboratory experiments.

Physical quality analysis

Quantities of the submitted sample were 125 g and the working sample was 62.5 g which was measured using sensitive balance after remixing each sample by using Boerner divider. Each sample was sorted into three components that include (i) pure seed, (ii) other crop seed, and (iii) inert matter. The components were weighed on precise sensitive balance to the nearest two decimal places, and each component's percentage was determined (ISTA, 1976).

Standard germination

Four hundred (400) seeds of the pure seed component were divided into four replicates of 100 seeds which were then sowed on top of the germination box. To determine the germination percentage, the seeds were incubated at a temperature of 20°C for 8 days as specified by the procedures described in (ISTA, 2014). On the final day of the standard germination test, seedlings were grouped into (i) normal seedlings, (ii) abnormal seedlings (iii) dead seeds, and (iv) fresh seeds.

Shoot and root lengths

The seedling's shoot and root lengths were determined in the standard germination test after the final count. Ten normal seedlings were randomly selected from each replicate after 8 days of sowing. The shoot length was measured from the point of attachment to the embryo (endosperm) to the tip of the seedling. Similarly, the root length was measured from the point of attachment to the embryo (endosperm) to the tip of the root. The shoot and root length average was computed by dividing the total shoot or root lengths by the total number of normal seedlings.

Seedling dry weight

Ten randomly selected seedlings from each replicate were cut from the embryo and placed in the aluminum paper to be dried in an oven at 80°C for 24 hours. The dried seedlings were weighed using sensitive balance and the average seedling dry weights were calculated. Vigor index-I: Seedling vigor indices were calculated by using the formula suggested by (Reddy and Kahn, 2001) and expressed as whole numbers. It was calculated by standard germination (%) x with the average sum of the shoot and root length after 8 days of germination and Vigor index-II: By multiplying the standard germination with mean seedling dry weight.

Speed of germination

One hundred seeds were replicated into four from each sample and sown on top of the germination box and kept at room temperature (20°C) for a maximum of 8 x 24 h. The speed of germination (GS) was calculated based on the total number of seeds sown (Maguire, 1962). The number of normal seedlings was counted daily up to 8 days and divided by the number of days. The same was added till the final count as per the following formula.

$$GS = \frac{\text{Number of normal seedlings}}{\text{Number of days to first count (4)}} + \ldots + \frac{\text{Number of normal seedlings}}{\text{Number of days to final count (8)}}$$

Data Analysis

The analysis of variance (ANOVA) was computed for the laboratory parameters using the SAS software, version 9.4. The mean comparison was done using the least significant difference (LSD) test at a 5% level of significance.

Results and Discussion

The main attributes of quality considered in this study were physical purity, physiological quality, and seedling vigor. Samples of harvested seed from different treatment combinations were subjected to seed quality analysis and accordingly interpreted. The interaction of location with seed rate affected most of the seed quality parameter and seed yield. Most of the seed quality parameters of bread wheat were affected non-significantly by the interaction effect of location and row spacing, seed rate, and row spacing, and also location, seed rate, and row spacing had no significant effect on seed quality so, the result discussed based on the main effect of the combined result. While the interaction of seed rate and row spacing significantly ($P<0.01$) affected the seed yield of bread wheat at both districts the result discussed each location independently.

Seed Yield

Seed yield of bread wheat was significantly affected ($P<0.01$) by the seed rate and row spacing. Similarly, the significant interaction effect of seed rate and row spacing was observed on the seed yield of bread wheat ($P<0.01$). The highest (4.44 $t.ha^{-1}$) seed yield was obtained from the combination of 150 $kg.ha^{-1}$ seed rate with 20 cm row spacing but, statistically at par with 125 $kg.ha^{-1}$ with 20 cm and 150 $kg.ha^{-1}$ with 30 cm row spacing, while the lowest (3.8 $t.ha^{-1}$) seed yield was recorded from the combination of 75 $kg.ha^{-1}$ seed rate with 30 cm row spacing (Table 1). At Wonberema the lowest (2.39 $kg.ha^{-1}$) and the highest (3.31 $t.ha^{-1}$) seed yields were obtained from the combination of 250 kg ha^{-1} seed rate with 30 cm row spacing, or 175 $kg.ha^{-1}$ seed rate with 30 cm row spacing (Table 1). As the seed rate increased beyond 150 and 175 $kg.ha^{-1}$ the seed yield of bread wheat decreased at both locations, likely due to during the

Table 1. The effect of seed rate and row spacing on seed yield of bread wheat at Adet and Wonberema combined (2018 and 2019)

	Row spacing (cm) at			
	Adet		Wonberema	
Seed rate (kg.ha^{-1})	20	30	20	30
75	42.0abc	38.0c	30.0abcd	30.0abcd
100	38.0bc	43.1ab	27.1def	26.5ef
125	44.0a	41.0abc	28.4cde	31.7abc
150	44.4a	44.0a	30.5abcd	32.6ab
175	42.0abc	42.7ab	30.2abcd	33.1a
200	41.1abc	42.0abc	28.3cde	30.4abcd
225	43.8a	40.5abc	29.8abc	29.3bcde
250	41.9abc	40.6abc	30.0bcde	23.9f
Row spacing	**		**	
CV (%)	6.54		6.84	

Note : **represent highly significant difference at P<0.01. CV= coefficient of variance; means with the same letter within the column are not significantly different.

seed filling period the foods translocated from the leaf could be less because of high competition under the highest seed rate, as a result, the low seed would be produced as compared to the highest seed rate (Essam and Abd, 2014). The results obtained from this study were in line with that of Getachew (2004) in that a significant increase in grain yields of bread wheat crop was obtained from increasing levels of seed rates at 20 cm row spacing. Similarly, Hamid et al. (2002) reported that maximum grain yield was achieved with an increase in seed rate, while minimum grain yield was produced by low and highest seed rate.

One-thousand Seed Weight

One-thousand seed weights are an important yield determining component which is reported to be a plant genetic characteristic, therefore, it was less affected by environmental factors (Ayoub et al., 1994). The analysis of variance indicated that both main and interaction effects of seed rate and row spacing revealed non-significant differences on thousand seed weight (Table 2). However, as the seed rate increased thousand seed weights decreased; this might be due to high competition among spikes as a result of little assimilation available for grain filling and finally thousand kernels (seed) would be lower due to the high plant population. In conformity with this result, Jan et al. (2000) stated that as the seeding rate increased, the number of plants that emerged per unit area also increased, but the thousand seed weight decreased. Similarly, Mehrvar and Asadi (2006) reported that increasing seed rate will reduce a thousand grains weight of wheat, whereas Ayaz et al. (1999) reported that row spacing had significant effects on thousand seed weight.

Physical Purity Analysis

The combined mean square value revealed that seed rate and location significantly (P<0.05) affected most of the physical and physiological quality of bread wheat, however, row spacing, had a non-significant (P>0.05) effect on most physical and physiological quality. The analysis of variance showed that the main effect, as well as the interaction, had a non-significant (P>0.05) effect on the percent pure seed and inert matter of harvested seed. However, all treatments had met the national seed purity standards of Ethiopia (97%) and minimal impurities met the maximum prescribed standards (≤ 2%) described by (QSAE, 2000) for certified seed. In line with the present result, the same result was reported by (Geleta, 2017). The other crop seed was not significantly (P>0.05) affected by the main effect as well as interaction. In contrast to this finding Geleta (2017) reported that the highest other crop seed was observed when bread wheat varieties were sown at the seed rate of 200 kg.ha^{-1}. The presence of other crop seeds also met the national standards of other crop seeds (0.1%) except when wheat was sown at a seed rate of 200 kg.ha^{-1}. Contamination of the seed with other crop seeds might have occurred during harvesting and threshing. Similarly, Zewdie (2004) reported that significant differences in physical purity, other crop seeds, and weed seed contamination of wheat seed samples collected from different sources in Ethiopia

Table 2. The effects of seed rate and row spacing on physical and physiological purity and one-thousand seed weight of bread wheat (combined of Wonberema and Adet districts)

SR (kg.ha^{-1})	PS (%)	OCS (%)	IM (%)	NS (%)	ABS (%)	DS (%)	TSW (g)
75	99.77	0.00	0.22	86.25c	8.50b	3.13ab	31.90
100	99.73	0.00	0.30	89.19b	6.25cd	2.06cde	33.20
125	99.75	0.06	0.23	88.31b	7.56bc	1.69e	31.90
150	99.75	0.06	0.25	92.75a	4.25e	1.63e	33.40
175	99.73	0.00	0.26	91.69a	4.63de	1.94de	32.50
200	99.79	0.13	0.20	85.25cd	8.69ab	2.69bcd	32.20
225	99.78	0.00	0.22	84.44cd	9.13ab	2.81bc	32.00
250	99.80	0.00	0.20	83.75d	10.56a	3.75a	30.00
P (0.05)	ns	ns	ns	***	***	***	ns
Row spacing (cm)							
20	99.77	0.02	0.23	87.97	7.55	2.38	32.30
30	99.75	0.08	0.24	87.44	7.34	2.55	32.00
P (0.05)	ns	ns	ns	ns	ns	ns	ns
CV (%)	0.09	46.2	42.25	3.14	34.43	50.12	6.40

Note: Means in the column with the same letter are not significantly different at (p 0.05); PS=Pure Seed; OCS=Other Crop Seed; IM=Inert Matter; NS=Normal seedling; ABS=Abnormal seedling; DS=Dead seed; SPG=Speed of germination; SR=Seed rate; CV=Coefficient of variation, and LSD=Least significant difference

attributed to the different ways that farmers used to produce, select, save and acquire wheat seeds.

Standard Germination

Seed rate significantly (P<0.05) affected the number of normal, abnormal seedlings and dead seeds. Row spacing and the interaction of the two main factors were non-significantly (P>0.05) affected the normal seedlings, the abnormal seedlings, and the number of dead seeds (Table 4). As the seed rate increased from 150 to 250 kg.ha^{-1} normal seedlings decreased by 10.75 %, while abnormal seedlings increased by 148.47%. The maximum dead seed (3.75%) was obtained from the highest seed rate; when the seed rate increased from 150 to 250 kg.ha^{-1} the number of dead seeds increased by 130.06%. In line with the present result, Geleta (2017) reported that the highest percentage of the abnormal seedlings was obtained when the local variety was sown at the seeding rate of 200 kg.ha^{-1} ; generally the percentage of the abnormal seedlings for both varieties increased as the seeding rates increased from 125 to 200 kg.ha^{-1}. So, according to this study, all seeding rates and row spacing met the national standards of normal seedlings (85%) for a certified seed except seed rates of 200 and 250 kg ha^{-1} (QSAE, 2012). In conformity with the present finding (Geleta, 2017) also reported that the highest germination percentage of the normal seedlings were observed when the improved variety was sown at the seeding rates of 125 kg.ha^{-1} while the lowest mean value was recorded when the local variety was sown at the seed rate of 200 kg.ha^{-1}. Similarly, Alemayehu et al. (1999a) also reported that germination of harvested seed samples met the minimum standard for certified wheat seed production in Ethiopia. There was a significant difference in germination among seeds obtained from different seed rate sources.

Speed of Germination

Analysis of variance showed that seed rate (P<0.001) and row spacing (P<0.01) were significantly affected the speed of germinations, however, the interaction effect did not show significant differences (P>0.05). The highest and the lowest mean value were obtained from seed rates 150 and 250 kg.ha^{-1}, respectively. As the seed rate increased from 150 to 250 kg.ha^{-1} seed of germination decreased by 21.7% (Figure 1). The speed of germination indicates the rate at which the seeds are germinating rapidly and seedlings can emerge and quick adverse field conditions (Tekrony and Egli, 1991). Seeds that have high germination speed were found to be vigorous in the field and could be escaped harsh conditions (Maguire, 1962). Similarly, it is the rate at which the seeds are germinating and those seedlings with the higher index or highest on the first count are expected to show rapid germination and seedling emergence and to escape adverse field conditions (Zewude, 2004). Seeds with a low germination rate can have disastrous effects on a farmer's income by the time the seed would not germinate; it may be too late to plant again in that season (Matlon and Minot, 2007).

Seedlings Shoot Length

Seedling shoot length was highly significantly ($P \leq 0.01$) affected by the main effects of seed rate and row spacing but the interaction had no significant effect ($P>0.05$). The longest shoot (13.53 cm) was obtained from the seeding rate of 175 $kg.ha^{-1}$ but were observed from row spacing of 20 cm and 30 cm, respectively. The narrow row spacing gave better shoot length as compared to 30 cm row spacing.

Seedling Root Length

Seedling root length was significantly ($P<0.001$) affected by seed rate and row spacing but the interaction had no significant effect ($P>0.05$). The

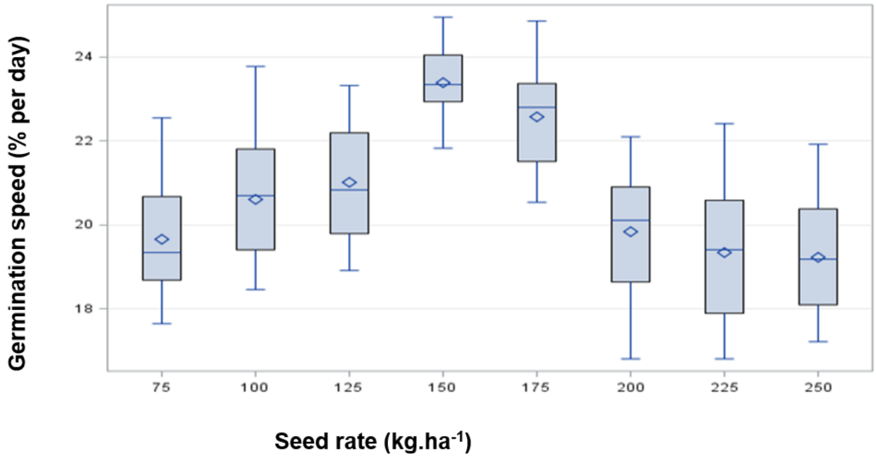

Figure 1. The effects of seed rate on the germination speed of bread wheat

statistically not apart from a seed rate of 150 $kg.ha^{-1}$ while the shortest shoot (11.02 cm) was obtained from the seeding rate of 200 $kg.ha^{-1}$ (Figure 2). This could be because plants sown at lower seed rates bear nutritionally well-developed seeds since there would be minimum competition for space, nutrients, and light among individual plants during the growth and development of the crop. Similarly, Zewude (2004) reported that seedlings with well-developed shoot and root systems would withstand any adverse conditions and provide better seedling emergence and seedling establishment in the field. The longest (12.19cm) and the shortest (11.82 cm) root length longest (16.87 cm) and the shortest (13.5) root length was observed from seed rate of 150 $kg.ha^{-1}$ and 250 $kg.ha^{-1}$, respectively, whereas the longest root length was statistically similar with 175 $kg.ha^{-1}$, as the seed rate increased beyond, 150 $kg.ha^{-1}$ the seedling root length decreased. It is assumed that seedlings with the well-developed shoot and root systems would withstand any adverse conditions and provide better seedling emergence and seedling establishment in the field (Zewude, 2004). The longest (15.31cm) and the shortest (14.33 cm) root were observed from row spacing of 20 cm and 30 cm, respectively (Table 3).

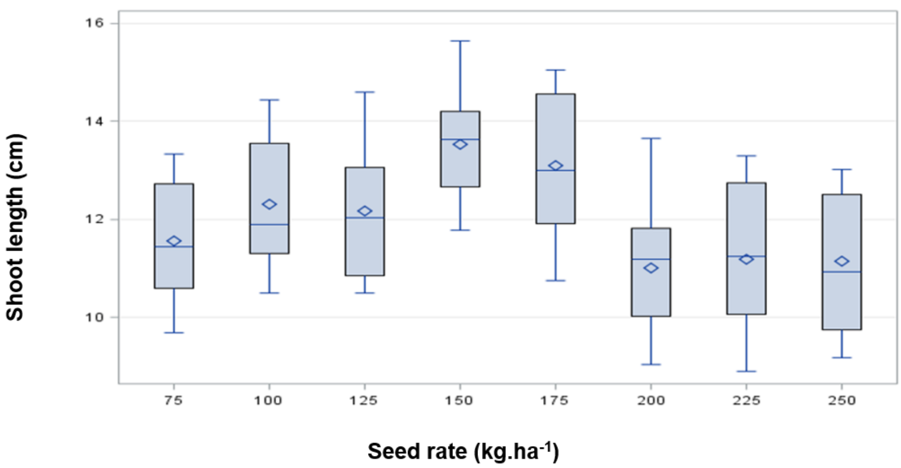

Figure 2. The effect of seed rates on shoot length of bread wheat

Seedling Dry Weight

Seedling dry weight was significantly (P<0.01) affected by the main effect of seed rate and row spacing but the interaction had no significant effect (P>0.05). The highest (0.59 g) seedling dry weight was obtained from seed rate of 150 kg.ha^{-1} and it was statistically similar with seed rate 175 kg.ha^{-1}. The lowest (0.27 g) seedling dry weight was from seed rate of 250 kg.ha^{-1}; as the seed rate increased from 150 to 250 kg.ha^{-1} the seedling dry weight decreased by 118.52 %. The maximum (0.46 g) and the minimum (0.39 g) seedling dry weight were obtained from row spacing of 20 cm and 30 cm, respectively (Table 3).

Seedling Vigor Index-I

The analysis of variance showed that seedling vigor index-I was affected by both seed rate and row spacing but the interaction had a non-significant effect on seedling vigor index-I. Seed vigor is an important quality parameter that needs to be assessed to supplement germination and viability tests to gain insight into the performance of a seed lot in the field or storage. Although differences in physiological attributes of seed lots can be demonstrated in the laboratory, it was recommended that the term should be used to describe the performance of seeds when sown in the field (Perry, 1984a). The highest vigor index-I (2819.54) was obtained from the seed sample harvested seed at 150 kg.ha^{-1} seeding rate, while the lowest (2068.23) was from the sample harvested seed at 250 kg. ha^{-1} seeding rate (Table 3). The vigor index-I decreased as the seeding rate increased for seed rates of 150 and 250 kg.ha^{-1}. Similarly, Vanangamudi et al. (2006) reported that the vigor index of any seed is the sum of those properties of seed that determine the potential level of activity that helps to withstand under a wide range of field conditions. The maximum (2425.91) and the minimum (2293.61) seedling vigor index-I was recorded from row spacing of 20 cm and 30 cm, respectively.

Seedling Vigor Index-II

The analysis of variance depicted that seedling vigor index-II was significantly affected by seed rate and row spacing (P ≤ 0.01), whereas the interaction had a non-significant effect. The highest (54.23) seedling vigor index-II was obtained from the seed sample harvested at a seeding rate of 150 kg.ha^{-1}, and it was statistically similar to seed rate 175 kg.ha^{-1}. The minimum (22.61) value was gained from the seed rate of 250 kg.ha^{-1}. The present result was in agreement with Gore et al. (1997) who reported that higher seedling vigor index II was probably due to the associated effect of germination percentage and seedling length. Similarly, Basra (2002) also reported that a practical seed vigor test should give a good indication of the field performance potential of the seed lot and the test results should be reproducible. The maximum (40.36) and the minimum (34.33)

Table 3. The main effect of seed rate and row spacing on seedling vigor of bread wheat (combined of Wonberema and Adet districts).

Seed rate (kg.ha^{-1})	RL (cm)	SDW (g)	Seedling vigor index-I	Seedling vigor index-II
75	14.6bc	0.42bc	2255.16d	36.35c
100	14.23bcd	0.39cd	2367.06c	34.65cd
125	14.79b	0.47b	2380.17c	41.24b
150	16.87a	0.59a	2819.54a	54.23a
175	16.4a	0.57a	2706.3b	52.18a
200	14.34bcd	0.37d	2163.1de	31.35d
225	13.81cd	0.31e	2118.52e	26.16e
250	13.5d	0.27e	2068.23e	22.61e
P (0.05)	***	***	100.98	4.59
Row spacing (cm)				
20	15.31a	0.46a	2425.91a	40.36a
30	14.33b	0.39b	2293.61b	34.33b
P (0.05)	**	***	***	***
CV (%)	8.31	17.85	6.09	17.51

Note: Means in the column with the same letter are not significantly different at (p<0.05); TSW=Thousand seed weight; RL=Root length and SDW=Seedling dry weight.

seedling vigor index-II was recorded from row spacing of 20 cm and 30 cm, respectively (Table 3).

Conclusion and Recommendation

Based on the results of this study, different seed rates and row spacing had significant effects on the seed quality of the Kekeba bread wheat variety. Most of the quality parameters of bread wheat were significantly affected by seed rate while some of the quality parameters were affected by row spacing. Overall, the results of the study showed that in Adet, high-quality seed was obtained when bread wheat was sown at a seed rate of 125 $kg.ha^{-1}$ with 20 cm row spacing, or 100 $kg.ha^{-1}$ with 30 cm row spacing. At Wonberema a seed rate of 125 $kg.ha^{-1}$ with 30 cm row or 150 $kg.ha^{-1}$ with 30 cm row spacing gave high-quality seeds. As the seeding rate increased from 125 to 250 $kg.ha^{-1}$ the values of vigor-I, vigor-II, seedling dry weight, seedling shoot and root length, thousand seed weight, speed of germination, and percent of pure seed and normal seedlings were declined. Therefore, seed producers and farmers in Adet can increase seed yield and quality if they used a seed rate of 125 $kg.ha^{-1}$ with 20 cm row spacing, whereas in Wonberema, a seed rate of 150 $kg.ha^{-1}$ or 125 $kg.ha^{-1}$ with 30 cm row spacing are recommended as the 1st and the 2nd option for bread wheat seed production.

Acknowledgements

The authors gratefully acknowledge Amhara Agricultural Research Institute (ARARI) and Adet Agricultural Research Center (AARC) for financing this research and seed technology directorate for their support during the laboratory seed quality test study.

References

Alemayehu, Z., R.Ensermu, B., Yaie, B., Girma, G.Taye, and Hassena, M. (1999). Farmer's Feedback on the status of released bread wheat varieties in Chilalo awaraja, Arsi Zone, Ethiopia, 106-113. *In* "10th Regional Wheat Workshop for Eastern, Central, and Southern Agriculture", 14-18 September 1998, University of Stellenbosch South Africa. CIMMYT, Addis Ababa, Ethiopia.

Assefa, W., Yemane, N., and Dawit, H. (2015). Planting density, and nitrogen and phosphorus fertilization effect on different bread wheat (*Triticum aestivum* L.) genotypes in Southern Tigray, Ethiopia. *World Science Research Journal* **3**, 20-28.

Ayaz, S., Shah, P., Sharif, H.M., and Ali, I. (1999). Yield, yield components and other important agronomic traits of wheat as affected by seed rate and planting geometry. *Sarhad Journal of Agriculture* **15**, 255-262.

Ayoub, M., Guertin, S., Lussier, S., and Smith, D.L. (1994). Timing and levels of nitrogen fertility effects on spring wheat. *Crop Science* **34**, 748-750.

Basra, A., S. (2002). "Seed Quality, Basic Mechanisms, and Agricultural Implications" Daryaganj, New Delhi, India.

Beavis, C.H.S, and Harty, R.L. (1999). Seed quality assurance, producing high-quality seed. Pp. 289-291. *In* "Forage Seed Production, Tropical and Sub-Tropical Species" (D.S. Loch and J.E. Ferguson, eds) J.E. CABI publishing. UK.

CIMMYT (International Maize and wheat improvement center). (1988). "From Agronomic Data to Farmer Recommendations: An Economics Training Manual". Revised edition. Mexico.

CSA (Central Statistical Authority) (2019/20). Report on area and production of major crops *In* "The Republic of Ethiopia Agricultural Sample Survey Statistical Bulletin". Addis Ababa, Ethiopia.

Essam, A. and El-Lattief, A. (2014). Determining the optimization seeding rate for improved productivity of wheat under Southern Egypt conditions. *International Journal of Agroecology and Agricultural Research* **4**, 47-57.

Gastel, A.J., Van, G., Bishaw, Z., and Gregg B.R. (2002). Wheat seed production *In* "Bread Wheat" (B.C. Curtis, S. Rajaram, H.G. Macpherson, eds.). Food and Agricultural Organization (FAO), Rome, Italy.

Geleta, T. (2017). Seed rate and sowing method effects on seed quality of bread wheat (*Triticum aestivum* L.) varieties in Horo District, Western Ethiopia. *Malaysian Journal of Medical and Biological Research* **4**, 117-128.

Getachew, F. (2004). "Soil Characterization and Bread Wheat (*Triticum aestivum*) Response to N and P Fertilization on Nitisols at Ayehu Research Substation in Northwestern Ethiopia". [Thesis]. School of Graduate Studies, Alemaya University. 71p.

Gore, S. V., Patil, R. B., and Wankhade, G. R. (1997). Effect of maturity period and harvesting time on seed quality in soybean (*Glycine max* [L.] Merill) cultivars. *Seed Research* **25**, 45-49.

Hamid, E. F., H. J., Bakht, A.W., Shah, and Shad, A.A. (2002). Effect of different planting dates, seed rates, and nitrogen levels on wheat. *Asian Journal of Plant Science* **1**, 502-506.

International Seed Testing Association (ISTA) (1976). International rules for seed testing. *Seed Science and Technology* **4**, 51-77.

International Seed Testing Association (ISTA) (2003). “International Rules for Seed Testing”. The International Seed Testing Association.

International Seed Testing Association (ISTA) (2014). International rules for seed testing. *Zürichstr* **50**, CH-8303.

Jan, A., Hamid, I., and Muhammad, T.J. (2000). Yield and yield components of wheat as influenced by seeding rates and sowing dates. *Pakistan Journal of Biological Science* **3**, 323-325.

Maguire, J.D. (1962). Speed of germination aid in selection and evaluation for seedling emergence and vigor. *Crop Science* **2**, 176-177.

Matlon, P., and Minot, N. (2007). "Seed Development Programs in Sub-Saharan Africa: A Review of Experiences".

Mehrvar, M.R., and Asadi, H. (2006). Agronomical and economical assessment of planting methods and seeding rates in irrigated wheat (*Triticum aestivum* L.). *Journal of Agronomy* **5**, 626-633.

Minale, L., Alemayehu, A., Tilahun, T., Abreham, M. (2006). Effect of nitrogen and phosphorus fertilizers on the yield of bread wheat (*Triticum aestivum*) in major wheat-growing areas of northwestern Ethiopia. *In* ‘’Proceedings of the 1st Annual Regional Conference on Completed Crop Research Activities’’ pp. 84–90. Amhara Regional Agricultural Research Institute, Bahir Dar, Ethiopia,.

Mugonozza, S., G.T. (2001). “Seed System in Agriculture”. International Center for Agriculture Research in the Dry Areas. ICARDA.

Nizamani, G.S., Tunio, S., Buriro, U. A., and Keerio, M. I. (2014). Influence of different seed rates on yield contributing traits in wheat varieties. *Journal of Plant Sciences* **2**, 232-236.

Oleksiak, T. (1998). Wplyw kwalifikowanego materialu siewnego na plonowanie zboz [Influence of certified seeds on cereal yields]. *Biuletyn Instytutu Hodowli i Akilimatyzacji Roslin* **208**, 3–9.

Peter, J., Cerny, V., and Huska, L. (1988). “Development in Crop Science: Yield Formation in the Main Field Crops". Elsevier Science, New York, USA. 336 p.

QSAE (Quality and Standards Authority of Ethiopia). (2012). “Hybrid Maize Seed- Specification”. Ethiopian Standards ES 420. Addis Ababa, Ethiopia.

QSAE (Quality and Standards Authority of Ethiopia). (2000). “The Minimum Requirement for Wheat Seed Certification ES 414”. www.ethiostandards.org [January 10, 2022].

Reddy, Y., T. N., and Khan, M. M. (2001). Effect of osmo-priming on germination, seedling growth, and vigor of khirni (*Mimusops hexandra*) seeds. *Seed Research New Delhi* 2**9**, 24-27.

Tekrony, D.M., and Egli, D.B. (1991). Relationship of seed vigor to crop yield. *Crop Science*, **31**, 816-822. DOI: https://doi.org/10.2135/cropsci1991.0011183X003100030054x

Tripp, R., Louwaars, N. P., van der Burg, W. J., Virk, D. S., and Witcombe, J. R (1997). “Alternatives for Seed Regulatory Reform: An Analysis of Variety Testing, Variety Regulation, and Seed Quality Control”. Agricultural Research and Extension Network. Network Paper No. 69. Overseas Development Institute, London, UK.

Vanangamudi, K., Natarajan, N., Bharathi, A., Umarani, R., Natarajan, K., and Saravanan, T. (2006). “Advances in Seed Science and Technology”. 21p.

Vieira, R.D., Paiva-Aguero, J.A., Perrin, D., and Bittencourt, S. (1999). Correlation of electrical conductivity and other vigor tests with field emergence of soybean seedlings. *Seed Science and Technology* **27**, 67-75.

White, J.W., Tanner, D.G., and Corbett, J.D. (2001). “An Agro-Climatological Characterization of Bread Wheat Production Areas in Ethiopia”. NRG-GIS Series 01-01. CIMMYT, Mexico.

Zecevic, V., Jelena, B., Desimir, K., and Danica, M. (2014). Effect of seeding rate on grain quality of winter wheat.” *Chilean Journal of Agricultural Research* **74**, 23-28.

Zewude, B. (2004). “Wheat and Barley Seed Systems in Ethiopia and Syria”. [Thesis]. Wageningen University.

Zhang, J., Dong, S., Dai, X., Wu, T., Wang, X., Bai, H., and He, M. (2016). The combined effect of plant density and nitrogen input on grain yield, nitrogen uptake, and utilization of winter wheat. *Vegetos Journal* **29**, 2. DOI: http://dx.doi.org/10.5958/2229-4473.2016