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Effect of Seed Rates and Sowing Methods on Yield and Yield Components of Bread Wheat (*Triticum Aestivum L.*) Varieties in Toke Kutaye District, Oromia Regional National State, Central Ethiopia

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Abstract

Bread wheat *(Triticum asitivum L.)* is one of a very important cereal crop produced in central highlands of Ethiopia. However, its yield has been low due to various reasons such as lack of improved varieties and optimal seed rate, improper sowing methods, and poor agronomic practices among others. This in view an experiment was carried out to determine the effect of seed rates and sowing methods on the yield and yield components of bread wheat varieties in Toke Kutaye district, central Ethiopia during 2021 cropping season. The treatments consisted of factorial combination of three levels of seed rates (125, 150 and 175 kg ha^{-1}), two sowing methods (row planting and broadcasting), and three bread wheat varieties (Shorima, Wane and Lemu).The treatments were arranged in randomized complete block design in a factorial arrangement with three replications. The result of the study showed that the three way interaction of varieties, sowing methods and seed rates were significantly ($P<0.05$) affected the number of kernels per spike and spike length, two-way interaction effect of varieties with sowing methods and varieties with seed rates significantly ($P<0.05$) affected Dry Biomass, the main effects of varieties, sowing methods and seed rates, two- way interaction and three way interaction were significantly ($P<0.05$) affected straw yield, thousand grain weight, grain yield and harvest index. The interaction effects of varieties with sowing method and varieties with seed rate, were significantly ($P<0.05$) affected plant height, and the main effects of varieties had significant ($P<0.05$) variation on number of days to 50% heading of bread wheat varieties. The highest plant height (92.63cm) was recorded from Lemu variety combined 175 kg ha^{-1} and total tillers per plant(5.02), highest productive tiller from Shorima varieties, longer spike (8.49 cm and 8.72 cm) and highest number of kernel per spike (59.4 and 60.34) obtained from Shorma and Lemu varieties using at 150 kg ha^{-1} in row planting respectively. While the maximum dry biomass (11.37 t ha^{-1}) was obtained from 125 kg ha^{-1} row planting and 150 kg ha^{-1} with broadcasting. Similarly the maximum straw yield was obtained from the combination of the Wane variety with 125 kg ha^{-1} seed rates, by row planting method (10.23 t ha^{-1}), highest thousand seed weight (41.33 g) was obtained from the Lemu and Shorima varieties with 125 kg ha^{-1} with combination of row planting. The higher grain yield (4.17 t ha^{-1}) and harvest Index (43.07%) were recorded from Lemu variety by using 125 kg ha^{-1} seed rates with row planting method. The maximum net benefit (180,710ETB ha^{-1}) with marginal rate of return 1098.96% was recorded on 125 kg ha^{-1} seed rate with row planting on Lemu variety. Therefore, based on this study the use of Lemu variety at a rate of 125 kg ha^{-1} with row planting was recommended for bread wheat production in Toke Kutaye district and similar agro-ecology.

Keywords: Seed rate; Sowing method; Varieties

Introduction

Wheat *(Triticum aestivum L.)* is one of the most important cereal crops of the world and is a staple food for about one third of the worlds' population (Tadesse et al., 2017). Uthaya (2010) reported that it provides a large proportion of the world's nutrition compared to nutrition from other cereal grains and also wheat is primarily used as a staple food providing more protein than any other cereal crop and it ranks first in the world cereal production and sub-tropical regions of the world [1]. On top of that Bren et al. (2017) reported that it was a major food grain of the globe, and considered one of the three main cereals feeding the world population. FAO (2014) reported that the world annually wheat feeding by human may be one-fifth of the population and is a staple food of about one third of the worlds. Cakmak et al. (2008) stated that wheat provides 28% of the world's edible dry matter and up to 60% of daily calories in developing countries. Cooper (2015) reported that from the species of wheat; bread wheat is the major and most cultivated wheat species in the world [2].

Though traditionally wheat was not only the leading staple crop in Sub-Saharan Africa (SSA), but it is becoming an important food crop because of rapid population growth associated with increased urbanization and change in food preference for easy and fast food such as bread, biscuits, pasta, noodles and porridge (Tadesse et al., 2018). Wheat (Triticum spp.) is one of the major cereal crops grown in the highlands of Ethiopia and this region is regarded as the largest wheat producer in Sub-Saharan Africa (Belete et al., 2018) [3]. In Ethiopia wheat has become one of the most important cereal crops in Ethiopia ranking in total grain production (5.78 million tons) and in area coverage (1.89 million hectare) next to Teff, Maize and Sorghum (CSA, 2021) It is largely grown in the highlands of the country and constitutes roughly 10 % of the annual cereal production and the crops is grown at an altitude ranging from 1500 to 3000 meters above sea level between 6016' N latitude and 35042' E longitudes. But the most suitable agro-ecological zones, falls between 1900 and 2700 meters above sea level and the major wheat producing areas in Ethiopia were Arsi, Bale, Shewa, Ilubabor, Western Harerghe, Sidama, Tigray, Northern Gonder

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and Gojam zones (Bekele et al., 2000) [4]. According to GAIN (2021) annual report it stated that Ethiopia remains a net importer of wheat, satisfying around 25 per cent of the local demand with wheat imports. A significant share of imported wheat, mainly from the United States comes to Ethiopia as food aid rather than commercial purchases making the country one of the largest food aid recipients in Africa. Despite the long history of wheat cultivation and its importance to the Ethiopian agriculture, its average yield is still not exceeding 3.11tha^{-1}(CSA, 2021) [5]. The reason for yield decline of bread wheat could be mainly due to the use of low yielding local variety by farmers, weeds, diseases, insect pests, low soil fertility and moisture stress in the major wheat growing areas (Siddique et al., 2012). Similarly, Kumera et al. (2020) reported that poor agronomic like, inappropriate seeding rate, improper of sowing method and use of local varieties are one the big problem to cause the declination of yield in Ethiopia. Not only this factor but also time of sowing, traditional sowing methods, low seed rate and improper row spacing are very important (Iqba et al., 2010). Many farmers in developing countries prefer to use a higher seed rate than recommended, because they perceive it as a good strategy to control weeds and reduce the risks of crop production failure [6]. Planting with higher seed rate than the recommended rate is not encouraged because of its negative impact on seed quality, particularly on seed size and weight (Bezabih, 2020). Kumera et al. (2020) reported that use of improved varieties and seeding rates were significantly improved phenology, growth and grain yield of bread wheat. However, Woldekiros (2020) reported that instead of using higher seed rates, farmers must pay close attention to all recommended seed production practices [7]. Moreover, sowing method determines the area available to each plant which in turn determines nutrient and moisture availability to the plant. Row spacing determines resource availability and utilization by individual plants in each species. If the row is too wide, the crop is unable to rapidly shade the inter-row area to capture sunlight and weeds quickly become established. If the row is too narrow, inter-row crop competition results in poorer yields, difficulties in disease and insect control, and greater likelihood of lodging (Rahel and Fekadu, 2016). Therefore, identifying of optimal seed rate, appropriate sowing method, for varieties of bread wheat at specific location has significant value to increase the production and productivity of bread wheat [8].

Statement of the problem

Wheat production in Ethiopia is limited to smallholder farmers who use rain fed agriculture and are not able to produce enough to feed the growing population of the country, currently estimated to be more than 110 million people due to different constraints (GAIN, 2021). Bread wheat has been selected as one of the priority strategic crops by the Government of Ethiopia for solving the food security challenges in the country (GAIN, 2014).Wheat production in Ethiopia faced immense production constraints that are affecting both its yield potential and industrial quality (Amare et al., 2015) [9]. Similarly, Iqbal et al. (2011) reported that appropriate seeding rate is considered an important management factor for increasing wheat yield. It has a particular importance in wheat production because it is under the control of farmers in many cropping systems. The majority of farmers in the developing countries are using either below or above the optimum recommended seed rates causing a wider yield gap between the potential and the actual production [10]. In Ethiopia, despite the need for optimum wheat seed rates disaggregated on spatial, temporal, and varietal levels, seed rate recommendations are still based on blanket recommendations of a “one-size-fits- all” approach and Ethiopian farmers cultivate both local and certified seeds of wheat varieties. However, the coverage of certified seeds of improved varieties is quite low (Atlawu and Korbu, 2011) [11].

Moreover, the contribution of certified seed in boosting productivity and enhancing the livelihood of farmers can be realized if seeds are not recycled or are replaced by new seeds based on expected utility. The use of improved certified seeds without a parallel adoption in other agronomic practices, such as seed rates, seed replacement, spacing, and tillage, did not bring a substantial increase in bread wheat productivity. But also optimum seeding rate and suitable cultivars play an important role in achieving potential yield of bread wheat (Nizamani et al., 2014) [12]. In Ethiopia there is no specified seed rates recommendation for specific location. However some authors recommend 125kg ha^{-1}, and few of them recommends 150kg ha^{-1} and others are recommends more than those mentioned seed rate because there no specific location recommendation for many varieties of bread wheat that has been released from different Agricultural research centres. At the same time those varieties were not well known at farmer’s level in specific location and there is no well-done large scale demonstration and adaptation at farmer’s level at specific area to increase productivity and production of bread wheat [13].

Therefore, the productivity of bread wheat in Ethiopia is low due to poor agronomic management practices and improved technology usage. Moreover lack of improved varieties, optimal seed rates, and appropriate sowing method for specific location and specified agro-ecological area causes the reduction of productivity and production of bread wheat. Therefore, this research was initiated to test the right varieties, seed rate, and sowing method for increasing the production and productivity of bread wheat at Toke Kutaye area or similar agro-ecology [14,15].

Objectives

General objective

- To improve production and productivity of bread wheat varieties through determining best sowing method and optimal seed rates in Toke Kutaye district, Oromia, central Ethiopia.

Specific objectives

- To determine the optimum seeding rate of bread wheat varieties in Toke Kutaye district

- To evaluate the effect of sowing methods on yield and yield components of bread wheat varieties in Toke Kutaye district

- To evaluate the interaction effects of seeding rate and sowing method on yield and yield components of bread wheat in Toke Kutaye district

Literature Review

History and evolutionary processes of bread wheat

The process, which began some ten thousand years ago, involved the following major steps. Wild einkorn T.urartu crossed spontaneously with Aegilops speltoides to produce Wild Emmer T. dicoccoides; further hybridizations with another Aegilops (A. taushi), gave rise to Spelt (T. spelta) and early forms of Durum Wheat (cultivated emmer); Bread wheat finally evolved through years of cultivation in the southern Caspian plains [16]. This evolution was accelerated by an expanding geographical range of cultivation and by human selection and had produced bread wheat as early as the sixth millennium BC. Modern varieties are selections caused by natural mutation starting with emmer wheat up to husk less modern wheat (Zhou et al., 2020) [17].

Cytological and cytogenetic evidence shows that wheat consists of diploid, tetraploid and hexaploid (two, four and six sets of chromosomes respectively) species with a basic chromosome set of x=7. Three genomes designated as A, B (G), and D was involved in the formation of the polyploidy series (Feldmann, 2001). T. urartu and Aegilops squarossa *(syn. Triticum tauschii)* are the diploid progenitors of the A and D genomes, respectively [18]. It is believed that T. monoccocum naturally hybridized with the yet unknown B-genome donor to give rise to the tetraploid emmer group. Emmer wheat in turn hybridized with Ae. Squarossa and a spontaneous chromosome doubling of the triploid resulted in the formation of hexaploid wheat (Feldmann, 2001). However, the challenge for global nutrition is to increase grain yield per unit area while maintaining its end use value (Nandi et al., 2018). Wheat is not only for making bread, biscuit and pastry products, but also to produce starch and gluten; the raised bread loaf is possible because the wheat kernel contains gluten, an elastic form of protein that traps minute bubbles of carbon dioxide when fermentation occurs in leavened dough, causing the dough to rise (Rakkar and Pardeep Singh 2007) [19].

In Ethiopia, it is largely grown in the highlands of the country and constitutes roughly 10% of the annual cereal production and plays an appreciable role in supplying the population with carbohydrates, protein and minerals (Schultze's et al., 1997) [20]. Bread wheat *(Triticum aestivum L.)* also known as common wheat, is an annual, predominantly auto-gamous species belonging to the Triticeae tribe of the grasses (Poaceae) family. It is an allohexaploid species, composed of 21 chromosome pairs organized in three subgenomes, A, B, and D, Genome BBAADD, $2n = 6x = 42$ and Its nutritious grain contributes an important fraction of the calorific daily intake in many parts of the world, for example, 40%-50% in Egypt and Turkey and ~20% in the UK (Sherwry and Hey, 2015). Similarly, Marcussen et al. (2014) reported the bread wheat evolved through two rounds of allopolyploidization. The first event led to the formation of tetraploid wild emmer wheat approximately 800,000 years ago following hybridization between two diploid species [21,22].

The two economically important wheat species grown in Ethiopia are Tetraploid durum (Triticum durum) and hexaploid bread wheat *(T. aestivum)* (Alemu et al., 2020). The production of bread wheat dominates the peasant farming systems in the mid to high altitude zones (Hassen et al., 2010). Its production is increasing rapidly du e to both a high local demand, and the availability of high yielding, input responsive cultivars adapted to heterogeneous environmental conditions (Abboye et al., 2010) [23].

Ethiopia is one of the principal wheat producer and importer of in East, Central and Southern Africa (Tadesse et al., 2019) But also, Ethiopia is the largest wheat producer in the Sub-Saharan Africa with about 0.75 million ha of durum and bread wheat (Bekele et al., 2014). Wheat is one of the major cereal crops in the Ethiopian highlands, which range between 6o and 16o N, 35o and 42o E, and from 1500 to 2800 masl. At present, wheat is produced solely under rain fed conditions (Gashaw et al., 2014). However, MOA (2018) reported that more than 300,000 ha were produced under irrigation during the off season [24].

According to Bekele et al. (2000) in Ethiopia about 60 % of wheat area is covered by bread wheat and 10 per cent by durum wheat from total wheat production area 75.5% which is located in Arsi, Bale, and Shewa zones. Also, stated 6% of the 13 million ha of cultivated area classified as highly suitable for bread wheat production is in Arsi, Bale, and Shewa. Altitude plays an important role in the distribution of wheat production through its influence on rainfall, temperature, and diseases (Alemu et al., 2016) [25,26].

Importance of bread wheat in Ethiopia

From the earliest times, 1900 AD, wheat has played an important role in the development of civilization. Substantial amounts of wheat are produced in tropical and sub- tropical environments, although the crop is the number one cereal of the temperate regions (Raseduzzaman et al., 2017). In Africa bread wheat is a traditional crops diverse form of preparation and consumption has great contribution in human food and daily consumption. Wheat is not only for making bread, biscuit and pastry products, but also used to produce starch and gluten (Noorfarahzilah et al., 2014) [27]. Wheat provides about 19 per cent of the calories and 21 per cent of protein needs of daily human requirements at the global level (Braun et al., 2010). Most of the wheat production goes to household consumption in different forms and is supplied to the local market. A quite large quantity of wheat also goes to agro-industries for processing flour wheat for making bread, injera (traditional Ethiopian pancake), macaroni, pasta, and other food types. The demand for bread wheat is increasing due to the expansion of bread flour factories in the country (Alemu, 2010). Ethiopia is the second-largest bread wheat producer in sub-Saharan Africa following South Africa solely under rain-fed conditions (Netsanet et al., 2017) [28,29].

According to Tadesse et al. (2019) in Ethiopia bread wheat sowing for long tradition and has been used solely for French bread or in mixture with other cereals (barley, maize, sorghum, rice and millet) for the preparation of other dishes such as flat bread (Injera), porridge, boiled grain (Nifro), roasted grain (kolo), Soup and preparation of local beer (Tela and Areke). But also, it is a major pillar for food security due to its high value as a staple food for about more than 85% population of the country Minot et al. (2015). CIMMYT (2021) stated that bread wheat stands out as a success story of the ambitious agricultural product development goals of the Ethiopian government to improve the food security status of millions of household livelihoods [30].

Bread wheat is used in different forms such as bread, porridge, soup, dabo kolo and roasted grain. In addition to the grain, the straw of the wheat is used for animal feed, thatching roofs, cementing the mud for house construction and bed decking. Despite its tremendous importance, the economic value of wheat straw is often overlooked [31].

Effect of sowing method on bread wheat

Among the factors responsible for low bread wheat yield, delay in sowing, traditional sowing methods, low seed rate and improper row spacing are very important (Iqba et al., 2010). Similarly, Iqba et al. (2010) reported that traditional sowing method (broadcasting) was cause yield reduction in bread wheat production [32].

Wato et al.(2020) reported that Planting methods have a countless role in reducing bread wheat production and being one of the most important agronomic factors plays an essential role in seed placement at an appropriate depth, ensure enhance seed emergence and succeeding crop growth. Bread wheat planted in drilling mostly to increase yields and for convincing [33]. But the restriction to drill sowing wheat by hand in Ethiopia is that the high labour and time requirement. It agrees with (Awoke et al., 2017) sowing method had brought significant effect on the grain yield of bread wheat in south

Omo of Ethiopia Drilling sowing method has a significant effect on plant height and numbers of tillers per plants. He further stated that wheat planted by drilling method resulted in taller plants up to 101.95 cm followed by seed broadcasting 97.49 cm and in drilling methods, the result show that the wheat produces a greater number of tiller (10.32/Plant) than broadcasting methods and higher mean number of grains per spike was achieved in plants through drilling sowing method (60.60/spike) [34]. While the lowest number of grains/spikes was recorded in plants through broadcasting (Umed et al., 2009). In contrary Pirzada et al. (2018) stated that drilling method of planting recorded significant maximum tillers m-2 of bread wheat as compared to 400 tillers m-2 broadcasting method of sowing. Furthermore, Sikander (2003) reported that on his finding planting methods had significant effect on the emergence of wheat highest number of wheat plants emerged with the drilling sowing method which was followed by broadcasted beds within a given day. Similarly Emmu (2018) reported on his finding significance difference for the height of the plant in drilling, dibbling and broadcasting sowing methods i.e. the highest plant height was recorded at drilling sowing method. Not only plant height but also, there had a significance differenced on numbers of tillers per plant [35]. Also, Assefa and Kassaye (2017) reported that the plant vigour and yield were significantly increased when bread Wheat sown at the seed rate of 150 kg ha^{-1} by drilling method and number of spikes per plant, thousand grain weight, number of grains per spike, grain and straw weight per plot are highest where seed rate maintain at 125 kg ha^{-1}. According to Hossain (2006), broadcasting produced a greater number of plants spikes per square meter, longer spike length and maximum grain weight than conventional methods. Grain yield also showed highest in bed planting due to higher yield attributes. In contrary Meleh et al. (2020) reported that bed broadcast planting method gave the highest mean values for all studied parameters except the plant height which was recorded with drilling seeds at a 15 cm planting method in the two growing seasons [36].

Effect of seed rate on bread wheat production

Seed rate is one of the most important agronomic factors which need great emphasis for maximum yield of crops. So, Adjustment of seeding schemes is one of the crop management techniques that most influences grain and yield components [37]. High seed rate increases the competition among crops for common resource particularly water, nutrients and sunlight which result in low quality and low yield. The seed rate is another agronomic aspect that manipulates the yield of wheat. Fayisa et al. (2023) reported stated that smallholder farmers in Ethiopia, particularly in most parts of Oromia, mostly planted wheat in broadcast using 150-200 $kgha^{-1}$ for many decades. Similarly, Adinewu (2015) reported that maximum grain yield of bread wheat was obtained from 150 kg•ha^{-1} seed rate at Kersa, Eastern Ethiopia. Also, Staggenborg et al. (2003) points out that in varieties that produce fewer tillers, higher seeding rates compensated for the reduced tiller. Similarly, Abboye et al. (2020) reported that the use of low seed rate leads to low yield due to lesser number of plants per unit area [38]. Whereas, Rafique et al. (2010) stated that an increase in the seed rate over optimum may increase production costs without enhancement in yield. Similarly, Baloch et al. (2010) reported lower seed rates significantly increased the number of fertile tillers produced per plant which do have pronounced effect on yield of varieties. According to Umed et al. (2009) wheat sown at higher seed rate i.e. 175 kg/ha produced greater plant height followed by 150 kg/ha and 125 kg/ha. Proper row spacing and seed rate are most important management factor affecting the agronomic characteristics of bread wheat (Ansari et al., 2006) [39.40].

Higher number of grains per spike was achieved in plants sown at seed rate 125 kg/ha through sowing method drilling. Likewise, Sharma et al. (2016) reported that there were variations in plant height in response to the different seeding rates; Wheat sown at higher seed rate 140 kg ha^{-1} produced taller plants up to 70.89 and 71.47 cm followed by wheat sown with 130 kg ha^{-1} and increase of 10.62 % in tiller was observed under seed rate of 140 kg ha^{-1} in comparison to 100 kg ha^{-1} also an Increased number of effective tillers m^{-2} could be ascribed to the increased plant population m-2 at seed rate of 140 kg ha^{-1}. Similarly Awoke et al. (2017) reported that the maximum grain yield of 3.9 t ha^{-1} and the minimum 2.7 t ha^{-1} were obtained from seed rate of 125 kg ha^{-1} and 200 kg ha^{-1} respectively. By increasing the seed rate, the number of grains per spike is reduced (Khan et al., 2002; and Mehrvar and Ansari, 2006). Higher seeding rates compensate for reduced tiller development and promote more main stem spikes which can be favorable, especially for cultivars that tend to produce fewer tillers (Forward et al., 2020) [41].

The number of productive tillers is dependent on varieties and environment and strongly influenced by planting density. However, tiller capacity is increased with enough moisture availability, increasing light and optimum nitrogen availability during the vegetative phase and it depends greatly upon varieties (Valerio et al., 2013). Plant height, number of tillers per plant, spikelet per spike, grains per spike, biological yield, grain yield and straw were significantly affected by different seed rates (Rahel and Fekadu, 2016) [42]. Whereas the decrease in plant height in response to lowering the seeding rate to 100 kg ha^{-1} may reflect formation of more secondary tillers in less populated stands, which tend to be shorter in stature (Abboye et al., 2020). Higher seeding rate caused to changing plant height and stem thickness because of the lower light penetrating the plants canopy bed and more inter specific competition to more absorption light (Haile et al., 2013). Similarly, Asefa et al. (2017) reported that the plant vigour and yield were significantly increased when wheat sown at the seed rate of 150 kg ha-1 by drilling method and the number of spikes per plant, number of grains per spike, thousand grain weights, grain and straw weight per plot are highest where seed rate maintains at 125 kg ha^{-1}. In another way, Fani et al. (2014) showed that at high densities thousand seeds weight declined whereas in low densities, seed thousand weights increased [43].

Similarly, Woldekiros (2020) reported that number of seeds per spike was significantly influenced by seeding rate and maximum number of seeds per spike (50.13) was obtained due to seed rate of 100 kg/ha and minimum number of seeds per spike (40.85) obtained from the seeding rate of 175 $kgha^{-1}$. Similarly, Fazily and Tamim (2021) reported that higher seeding rates compensate for reduced tillers formation and promote more main stem spikes which can be favourable, particularly for genotypes that tend to produce a smaller number of tillers [44]. However, some study conducted shows that the straw and above ground biomass yield increased with increasing seeding rate till 140 kg ha^{-1} (Intsar et al., 2017) Results revealed that all growth and yield parameters were significantly affected by the sowing methods and seed rates. Also, Abd El-Mohsen et al. (2013) Stated that seed rate varies significantly from region to region due to the difference of climatic factors, type of soil, sowing date, and genotypes [45]. Similarly with the present finding, Haile et al. (2013) reported that the lower seed rate resulted in lower grain yield while higher yield was due to higher seed rate. Whereas, Assefa and Mulatu (2017) reported that the use of different seed rates resulted in variations in days to 50% heading. According those authors Plants grown at the highest seed rate of 150 kg ha^{-1} attained early heading than seed rate of 100 kg ha^{-1}

and 125 kg ha^{-1} and the spike length was affected by seed i.e. seed rate increase from 100kg ha^{-1} to 150kg ha^{-1} it decrease the spike length [46].

Effect of varieties wheat production

The different varieties of bread wheat have a great significant to affects the crop yield and yield components like plant height, number of tillers m^{-2}, grains $spike^{-1}$, thousand grain weight and grain yield except the plant population m^{-2} which was not significantly influenced by the different varieties. According to Kumera et al. (2020) the spike length of bread wheat was very highly significantly affected by varieties. As well as the harvest index of bread wheat was very highly significantly affected by main effects of varieties, the highest harvest index was observed from Liben variety of wheat while lowest harvest index was recorded from Hidase variety [47]. Jemal et al. (2015) reported that harvest index in bread wheat was affected by varieties, Shorima and Kakaba varieties were gave significantly higher harvest index of bread wheat as compared to the other varieties. Similarly, Also, Kumera et al (2020) reported grain yield was significantly affected by varieties according to his findings the highest mean grain yield and thousand grain weight of bread wheat was obtained from Liben variety while the lowest mean 3.79 t ha^{-1} was for Hidase variety of bread wheat [48]. Similarly, Chimdessa et al. (2017) reported that significance difference of grain yield among varieties of bread wheat. Not only the grain but also varieties have a great effect on thousand grain weights and the significant variation in thousand seed weight between the varieties was obtained from Hidase and Ogolcho varieties as compared to Liben variety at Guji zone Oromia region. Similarly, a different variety of bread wheat has different days to 50% heading. Habtamu and Ahadu (2019) reported that days to 75% of heading of bread wheat was different among varieties and shorter days to heading was recorded form Kekeba variety and longer days to heading was revealed by variety (Jemal et al., 2015). Similarly, Assefa and Mulatu (2017) reported that days to 50% heading and spike length significantly affected by varieties under different seed rate [49].

Materials and Methods

Description of the study area

The experiment was conducted at Birbissa and Dogoma farmers' association; Toke Kutaye district, central Oromia during the main cropping season of 2021/2022. Toke Kutaye district was found at 132 Km away from the capital city of the country which is located at latitude of 8o 55'N and longitude of 37o 44' E in central Ethiopia. The altitude of the study site was 2112 meter above sea level and total annual rainfall during the cropping season 1238 mm per annual. It has a warm humid climate and maximum and minimum temperature of 27 and 8C0, respectively per annum. The predominant soil type of the area is reddish and black soil which characteristically reddish brown in colour. Maize, Tef, Barley and wheat are the major among the cereal crops and potato, cabbage, beet root, carrot and others are important vegetable crops grown in the area. Toke Kutaye community practiced mixed farming system (Figure 1).

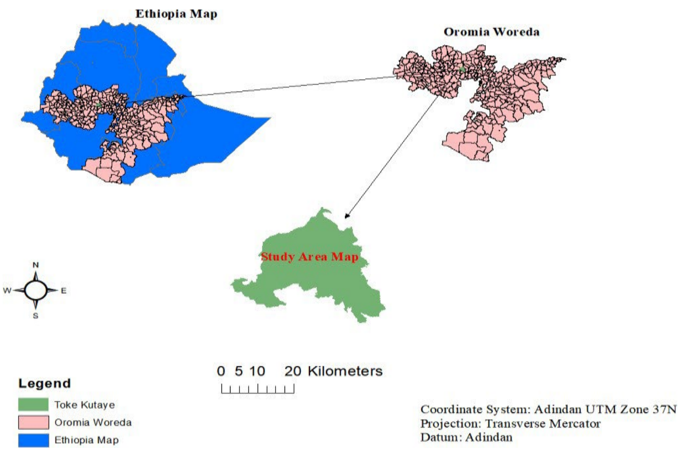

Figure 1: Map of the study area.

Table 1: Bread wheat varieties used for the experiment.

No.	Name of varieties	Year of release	Altitude	Rain falls	Days to maturity	Maintainer
1	Shorima	2011	1900-2600	600-900	105-150	KARC
2	Wane	2016	2100-2700	700-1000	125	KARC
3	Lemu	2016	>2200	800-1100	140	KARC
Source: MOA (2016) crop variety registration book No, 19						

Treatments and experimental design

The treatments include two sowing methods (row sowing and broadcasting), three seed rate (125, 150 and 175 kg ha^{-1}) and three varieties of bread wheat (Shorima, Lemu and Wane). The experiment was laid out in a randomized complete block design with a factorial arrangement of 2*3*3=18 treatment combinations in three replications. The plot size was 3m x 2m; and the distance between the plots and blocks were 0.5 and 1m, respectively. Seeds were sown in rows of 20 cm spacing by drilling and broadcasted based on the treatment. All field activities (land preparation, fertilizer application, and weeding) were done following the recommended agronomic practices (MOA, 2018) [50].

Experimental Materials

Bread wheat varieties (Shorima, Lemu and Wane) which were released by Kulumsa Agricultural Research Centre used for the experiment (Table 1). The varieties were high yielder, disease tolerant and adapted to the agro-ecology of the area and they have relatively the same area of adaptation and growing period. NPS mineral fertilizers containing 19 %N, 38% P and 7 % S, and Urea (46% N) were used as inorganic fertilizer source.

Experimental procedures and field managements

The land was ploughed four times following the conventional tillage practice by using, oxen driven local plough (Maresha) before planting the seed accordingly. The last ploughing was used get a fine seedbed and levelled manually before the field layout was made. A field layout was prepared, and each treatment was assigned randomly to experimental plots.

NPS fertilizer at the rate of 100kg ha^{-1} was applied in band along the rows and broadcasted just before sowing the seed based on the treatments, similarly Urea (100 $kgha^{-1}$) was applied by drilling in the rows and broadcasting based on the treatments with split application system, half of the during planting and the remaining twenty- five days after sowing for each plot except control (MoA, 2018). Weeding of experimental plot was done manually to keep free of weeds during the growth stage of the plants. Other agronomic practice was conducted uniformly according to the agronomic practice for wheat production. The crop was harvested when the color of the leaves completely changed to yellow and attains physiological maturity [51].

Data Collected

The data related to crop phenology, growth, yield and yield attributes were taken from pre-tagged plants and plots based on the standard procedures.

Crop phenology and growth parameters

Number of Days to heading was determined as the number of days taken from the day of sowing to the date of 50% heading.

Plant height: The average height of ten randomly selected plants from the net plot area of each plot was measured in centimetres from the ground to the top of spike, excluding awns at maturity and means were taken.

Yield component and Yield

Number of tillers per plant was determined from 20 randomly pre-tagged plants per plot at heading.

Number of productive tillers per plant was determined at maturity by counting all spikes producing seeds in two rows of 0.5m length per plant at physiological maturity.

Spike length: was measured from randomly selected plants of the middle rows in centimetre and the mean length was recorded on each plot by measured from the base to the upper most part of the spike excluding awns at maturity.

Number of kernels per spike: was counted from randomly selected plants from the middle rows of each plot and the mean number were taken at harvesting.

Dry biomass: was measured from plants harvested from the net plot area after sun dried for a week and converted to tons per hectare.

Straw yield: was obtained as the difference of the total above ground plant biomass and grain yield.

Thousand grain weight: was counted after threshing picking randomly from each plot and their weight measured with sensitive balance.

Grain yield: was recorded by measuring the weight of grains threshed from the net plot area of each plot and converted to kilograms per hectare after adjusting the grain moisture content to 12.5%.

Harvest index: was calculated as ratio of grain yield per plot to total above ground dry biomass yield per plot.

Data Analysis

The collected data was subjected to Analysis of Variance by using SAS statistical software (SAS, 2012) version 9.2. For a treatment that is significant, mean Separation was done using the Least Significant Difference (LSD) test at 5% probability level. Correlation between parameters was computed according to Gomez and Gomez (1984).

Economic analysis

The partial budget analysis was performed to investigate the economic feasibility of the treatments based on the procedure recommended for partial budget analysis (CIMMYT, 1988). The prices of seed, the market price of the grain and straw yields was obtained at harvest. Actual yield for grain and straws were adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same treatment. The wage costs for row planting and broadcast methods of sowing were 1200 and 350 birr ha^{-1}, respectively; while seed cost for Lemu, Shorima and Wane varieties were 65, 59.25 and 58.25 birr kg^{-1}, respectively. Moreover, grain yield (45 birr kg^{-1}) and straw yield 2.5 birr kg^{-1} were used for analysis. A treatment was considered worth to farmers when it's minimum acceptable rate of return (MAR) is 100% (CIMMYT, 1988), which is suggested to be realistic.

Results and Discussion

Crop phenology and growth

Number of days to 50% heading

Main effects of varieties had significant (P<0.05) variation on number of days to 50% heading of bread wheat varieties. But main effects of the sowing method and seed rate, and interaction effects were showed non-significant effects on number of days to 50 % heading of bread wheat. Shorima and Wane varieties reached to 50% heading earlier (63 days), while variety Lemu was late (69.61 days) as compared to the other varieties (Table 2). The difference in days to 50% heading among varieties could be attributed to the genetic factor. This result agrees with Kefale and Menzir (2019) who reported that the Lemu variety took a long period to reach the heading stage than Shorima and Wane varieties [52].

Plant height

.The interaction effects of varieties, sowing method and seed rate were significantly (P<0.01) affected plant height of bread wheat. Variety Lemu at 175 kg ha^{-1} seed rate with broadcasting planting method produced the tallest plant height (92.63cm). While, the shortest plant height (84 cm) was recorded from 150 kg ha^{-1} seed rate of variety Wane by broadcasting method of sowing. As seed rate increased from 125kgha^{-1} to 175kgha^{-1} the plant height also increased, this could due to their genetic deferential for light radiation, other growth resources. As increasing the seed rate on specific area, it also promotes competition between plants for survival and at high seed rates there a competition

Table 2: Interaction effects of varieties x seed rates x sowing methods on number of days to 50% heading and plant height, of bread wheat.

Treatments		Crop Phenology and Growth	
Sowing methods	**Seed rates (kg ha^{-1})**	**Number of days**	**Plant height**
Varieties		To 50% heading	(cm)
	125	63.00b	89.13ab
Broadcasting	150	63.00b	89.40ab
Shorima	175	63.00b	89.07ab
	125	63.00b	88.47ab
Row planting	150	63.00b	88.47ab
	175	63.00b	88.80ab
	125	63.00b	87.77ab
Broadcasting	150	63.00b	84.00b
Wane	175	63.00b	85.80ab
	125	63.00b	85.60ab
Row planting	150	63.00b	86.47ab
	175	63.00b	85.67ab
	125	69.1a	89.53ab
Broadcasting	150	69.1a	91.20ab
Lemu	175	69.1a	92.63a
	125	69.1a	88.93ab
Row planting	150	69.1a	87.73ab
	175	69.1a	90.47ab
LSD (5%)		0.7	7.3
CV (%)		1.5	5.41

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

of solar radiation, nutrient and water. Similarly, Worsham et al. (2015) reported that the height of the crop is mainly controlled by the genetic makeup of a genotype, and it can also be affected by environmental factors.

Yield and yield component parameters of bread wheat

Number of total tillers per plant

All the main effect of varieties, sowing method, seed rate and interaction effects did not significantly (P>0.05) affect the number of total tillers per plant of bread wheat. However, greater number of tillers per plant (5.02) was observed from Lemu variety and the smallest tiller number from Shorima and Wane (4.80) and (4.84) respectively,. Tillering is regulated genotypically but is also influenced by the environment. The non-significant main effect was found by seed rate on the number of tillers per plant. As the seed rate increase from 125 kg ha^{-1} to 175 kg ha^{-1} number of tillers per plant decreases from 4.92 to 4.84. This can be because at lower sowing densities, plants can use different resources (sun radiation, water, soil nutrients, etc.) more efficiently, and competition among tillers is reduced. Similarly, Rahel and Fekadu (2016) reported plant height, number of tillers per plant, spikelet per spike, grains per spike, biological yield, grain yield and straw were significantly affected by different seed rates.

Number of productive tillers per plant

The main effect of sowing methods were significantly (P<0.05) affected the number of productive tillers per plant of bread wheat, while other main and interaction effects showed non-significant difference on number of productive tillers per plant. The highest number of productive tillers per plant (2.47) was obtained from broadcast method of sowing, while the lowest (2.11) was recorded from row methods of sowing (Table 3). This result agrees with Soomro et al. (2009) who reported that seed rate had significant effect on Productive tiller.

Spike length

The analysis of variance showed that the interaction effects of varieties with sowing methods, and varieties with seed rates, and the three-way interaction were significant (P<0.05) treatments except broadcast sowing methods with variety Wane at a seed rate of 125,150 and 175 kg ha^{-1}, (6.43, 6.37 and 5.97 cm), respectively. Longer spikes were observed at Shorima and Lemu varieties using at 150 kg ha^{-1} seed rate, row planting method obtained (8.49 and 8.72cm) respectively, which at par with all genotypes responded differently to spike length for varying seeding rates in wheat. In agreement with this study, Otteson et al. (2007) reported that individual effect on spike length of bread wheat [53].

Table 3: Main effects of varieties, sowing method, and seeding rate on number of tillers per plant, and number of the productive tiller of bread wheat.

Treatments	Number of total tillers per plant	Number of productive tillers per plant
Varieties		
Shorima	4.80	2.36
Wane	4.84	2.12
Lemu	5.02	2.4
LSD (5%)	NS	NS
Seed rates (kg ha^{-1})		
125	4.92	2.32
150	4.91	2.31
175	4.84	2.25
LSD (5%)	NS	NS
Sowing methods		
Broadcasting	4.93	2.47a
Row sowing	4.85	2.11b
LSD (5%)	NS	0.26
CV (%)	21.47	20.71
NS=not significant, Means followed by the same letter case in a column are not significantly different from each other at 5% level of significance		

Number of kernels per spike

The three-way interaction of varieties, sowing methods, and seed rates significantly (P<0.05) affects number of kernels per spike of bread wheat. The highest number of kernels per spike (60.34) was recoded from row planting method produced at a seed rate of 125 ha^{-1} on variety Lemu, which was statistically at par with all treatments except Wane variety. While, a smaller number of kernels per spike (48.33, and 49.67) was recorded from the combination of variety Wane with seed rate of 125 kg ha^{-1} and 150 kg ha^{-1}, (Table 4). This could be due to the reason that during the grain filling period the food trans-located from the leaf could be less because of high competition under the highest seed rate, as a result low grains would be produced and genetic makeup of individual varieties. The findings of this study agreed with those of Hussain et al. (2001), who claimed that increased grain number achieved at the lowest seed rate can be due to more light penetration through the plant canopy depending on varieties. The findings were also consistent with Mehrvar and Asadi (2006), who showed that increasing the seed rate reduced the number of grains per spike [54].

Dry biomass

The two-way interaction of the sowing methods with seed rates showed significant (P<0.05) effect on Dry biomass of bread wheat. However, the main effect of varieties, sowing methods and seed rates and other two way and three-way interaction did not significantly (P<0.05) affect the dry biomass of bread wheat. The maximum dry biomass, (11.37t ha^{-1}) was obtained from 125 kg ha^{-1} seed rates with the row method of sowing, which was statistically at par with 150 kg ha^{-1} seed rates with the broadcasting method, and 175 kg ha^{-1} seed rate with both methods of sowing. While the lowest dry biomass (9.49 t ha^{-1}) was recorded on 125 kg ha^{-1} seed rates with Broadcast sowing method (Table 5). Similarly, Mihiretu et al. (2019) reported that the highest above-ground biomass was obtained from Lemu variety at Tach Gayint western Amhara, Ethiopia [55].

Straw yield

The main effects of varieties, sowing methods, and seed rates, two-way interaction effects of varieties with seed rates, varieties with sowing methods, and sowing methods with seed rates, and three-way interaction were showed significant (P<0.05) effect on straw yield of bread wheat. The maximum straw yield (10.23 t ha^{-1}) was obtained from Wane variety with 125 kg ha^{-1} seed rates with row method of planting,

Table 4: Two-way interaction effects of sowing methods and seeding rates on the dry biomass of bread wheat.

Sowing methods	Seed rate (t ha^{-1})		
	125	150	175
Broadcasting	9.49b	11.03a	10.64a
Row sowing	11.37a	9.55b	10.64a
LSD (5%)		0.81	
CV (%)		8.14	
Means followed by the same letter in a column are not significantly different from each other at 5% level of significance.			

Table 5: Three-way interaction effects of varieties with seed rates with sowing methods on straw yield and thousand seed weight of bread wheat.

	Treatments		Straw yield (t ha^{-1})	Thousand seed weight (g)
Varieties	Sowing methods	Seed rates (kg ha^{-1})		
		125	7.77d	40.00ab
	Broadcasting	150	8.93b	39.33ab
Shorima		175	9.27abc	38.67b
		125	9.17abc	41.07a
	Row planting	150	8.50b	40.00ab
		175	9.93ab	34.00cd
		125	7.93c	38.67b
	Broadcasting	150	9.00abc	38.67b
Wane		175	9.57abc	33.33d
		125	10.23a	40.00ab
	Row planting	150	8.73bc	38.67ab
		175	8.73bc	38.67ab
		125	8.17cd	37.33c
	Broadcasting	150	8.90bc	33.33d
Lemu		175	8.57abcd	33.33d
		125	9.40abc	41.33a
	Row planting	150	8.70abcd	37.33c
		175	8.17cd	34.67cd
LSD (5%)			1.69	4.1
CV (%)			11.52	6.55
Means followed by the same letter in a column are not significantly different from each other at 5% level of significance				

Table 6: Three-way interaction effects of varieties, seed rate and sowing methods on grain yield and harvesting index of bread wheat.

Treatments				
Varieties	Sowing methods	Seed rates (kg ha^{-1})	Grain yield (t ha^{-1})	Harvest index (%)
		125	3.37cd	36.43c
	Broadcasting	150	3.47cd	32.83cd
Shorima		175	3.63bc	34.04cd
		125	3.97bc	37.08bcd
	Row planting	150	3.43cd	34.42cd
		175	3.93bc	34.51cd
		125	3.07ed	32.55de
	Broadcasting	150	3.30d	32.12de
Wane		175	3.13e	28.64e
		125	3.70c	32.00de
	Row planting	150	3.43cd	33.41d
		175	3.63bcde	35.93cd
		125	3.17e	33.58cd
Lemu	Broadcasting	150	4.03b	39.19b
		175	4.03b	40.97ab
		125	4.17a	43.07a
	Row planting	150	3.53bc	34.85cd
		175	4.13ab	38.41bc
LSD (5%)			0.78	8.67
CV(%)			12.98	14.83
Means followed by the same letter in a column are not significantly different from each other at 5% level of significance				

followed by Shorima variety (9.93 t ha^{-1}) with 175 kg ha^{-1} seed rate and row planting method, which was statistically at par with all treatment except Shorima variety, broadcasting method with 125 kg ha^{-1} seed rate, Wane variety broadcasting method with 125 kg ha^{-1} seed rate and Lemu variety broadcasting method 125 kg ha^{-1} and 175 kg ha^{-1} seed rates. While the lowest straw yield (7.77 tha^{-1}) was obtained from the Shorima variety with 125 kg ha^{-1} seed rate by the broadcasting method. In conformity with the present result, Fellahi et al. (2022) report that a higher straw yield (9.38 t ha^{-1}) was recorded under a seed rate of 125 kg ha^{-1} [56].

Thousand grains weight

The main effect of varieties, two-way interaction of varieties with sowing methods and varieties with seed rates; and the three-way interaction were showed significant ($P<0.05$) effect on thousand grain weight bread wheat. However, the main effect of the sowing methods and seed rates and other interaction effect did not significantly ($P>0.05$) affected thousand grains weight of bread wheat. The highest thousand seed weight (41.07 and 41.33g) was obtained from the combination of the Shorima and Limu varieties with 125 kg ha^{-1} seed rates by row planting method, respectively (Table 6),which was statistically at par with all treatment except variety Shorima row planting methods with 175 kg ha^{-1} seed rate, Wane variety broadcast method 175 kg ha^{-1} seed rate, Lemu variety with broadcasting method 125,150,175 kg ha^{-1} , and 150 and 175 kg ha^{-1} row planting method. This agreed with Geleta (2017) who stated that a significantly higher mean thousand seed weight was obtained from varieties. Similarly, Jemal et al. (2015) reported that the maximum value of a thousand seed weight (39.48 g) was recorded in the plot treated with a seed rate of 150 kg ha^{-1} for variety Shorima [57].

Grain yield

The main effects of varieties, sowing methods, seed rates, and the two-way interaction of sowing method with seed rate and the three-way interaction of varieties, sowing methods and seed rates were significantly (P<0.05) affected the grain yield of bread wheat Nevertheless, the interaction effect of varieties with sowing method, and varieties with seed rates did not significantly (P>0.05) affect the grain weight of bread wheat. The highest grain yield of bread wheat (4.17 t ha^{-1}) was obtained from Lemu variety with 125 kg ha^{-1} seed rates combined row sowing method, while lower grain yield of bread wheat (3.07 t ha^{-1}) was obtained from Wane variety with 125 kg ha^{-1}, seed rates combined with the broadcasting method of sowing. Also, Mihiretu et al. (2019) reported that, Lemu gave the highest yield (6.38 t ha^{-1}) followed by Kakaba in Tach Gayint. These results indicated that each variety must be sown at 125 kg ha^{-1} seed rate for row sowing and at 150 kg ha^{-1} seed rate for broadcasting. 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, number of productive tillers, and the like. Similarly, Tadesse et al. (2017) reported that maximum grain yield was obtained by using of seed rate of 125 kg ha^{-1} with the row planting method.

Harvest index

The main effect of varieties, interaction effect of varieties with sowing methods, and three-way interaction were significantly (P<0.05) affects harvest index of bread wheat, where as the main effects of the sowing methods and seed rate, interaction affects variety with sowing method, and sowing method with seed rate did not significantly (P>0.05) affected the harvest index of bread wheat. Lemu variety with row planting method at a rate of 125 kg ha^{-1}seed rate produced the maximum harvest index (43.07%), which was statistically at par with all treatment except Shorima variety with broadcast planting method and 150 kg ha^{-1}, and 175 kg ha^{-1} seed rate. This could be due to Lemu variety being better performance and disease resistant over Shorima and Wane varieties to the study area to have higher harvest index. The study agrees with Kefale and Menzir (2019) reported that Wane variety had the lowest harvest index (23.22%) and higher harvest index was obtained from Abola, Ogoloncho, and Shorima varieties due to their better Performance to disease reaction and genetic makeup in Debre Elias District, East Gojjam Zone, and North-western Ethiopia.

Pearson correlation coefficients between phenology, growth, and yield of Bread Wheat at Toke Kutaye district, central Oromia.

The simple combined correlation analysis was performed for the measured variables of growth, yield, and yield component parameters. The analysis result showed the presence of strong positive and significant (P ≤ 0.01) associations among growth, yield, and yield component parameters. Harvest index revealed a strong, positive, and highly significant correlation with most important agronomic traits, days to 50% heading (0.630***), number of productive tillers per plant (0.70***), spike length (0.449**), number of kernels per spike (0.468*), and grain weight (0.711***) and thousand seed weight (0.461*). On the other hand, the harvest index had a weak, positive, and insignificant correlation with plant height (0.25) and the number of tillers per plant (0.108), while a weak, negative and insignificant correlation with, dry biomass (-0.228ns), straw yield (-0.101ns). These results were in agreement with that of Sokoto et al. (2012) suggesting that the simple correlation coefficient of different crop parameters and grain yield indicated that most of the crop parameters viz. plant height, number of tiller m^{-2}, number of spike m- 2, spike length, number of grains per spike, and harvest index had a significant positive correlation with grain yield in both seasons and combined and this indicate their importance in yield determination [58].

The grain yield showed positive and significant association with days to 50% heading, (0.630**), spike length (0.449**), and harvesting index (0.82***) while the weak and non-significant correlation with the number of tillers per plant, above-ground biomass, and straw yield. Similarly Kefale and Menzir, (2019), reported a significant and positive correlations of yield with other agronomic traits i.e., days to 50% heading, days to 75% heading, days to 90% maturity, plant height, spike length, number of productive tillers per plant, number of kernels per spike, above-ground biomass, straw yield, and harvesting index. Mecha et al. (2017) also obtained a positive, strong, and highly significant correlation of grain yield with days to heading, days to maturity, plant height, the number of fertile tillers, spikelet per spike and spike length [59].

Conclusions and Recommendation

Conclusion

Number of days to 50% heading, Plant height, spike length, and all varied significantly (P<0.05) between varieties. Shorima and Wane Varieties reached days to 50% heading earlier (63 days), while variety Lemu was late (69.61 days) as compared to the other varieties. The largest plant height (92.63 cm) was obtained from Shorima variety using a 175 kg ha^{-1} seed rate with the broadcasting method greater number of tillers per plant (5.02) was observed from Lemu variety and the smallest tiller number from Shorima and Wane (4.80) and (4.84) respectively, the highest number of productive tillers per plant (2.40 and 2.36) was obtained from varieties Shorima and Lemu, using 125 and 175 kg ha^{-1} seed rates respectively, longer spikes (8.49 & 8.72cm), obtained from, Shorima and Lemu using a 150 kg ha^{-1} seed rate with the row planting methods respectively.

The number of kernels per spike, dry biomass weight, straw yield, thousand seed weight, grain yield, and harvesting index, all significantly affected by the three-way interactions of variety, seed rate, and sowing method. Shorima and Lemu Varieties at a seed rate of 150 kg ha^{-1} with row sowing method produced the highest number of kernels per spike (59.45 and 60.34) respectively. The maximum dry biomass (11.37 t ha^{-1}) was obtained from 125 kg ha^{-1} seed rates with the row method of sowing, while the maximum straw yield (10.23 t ha^{-1}) was obtained from Wane variety with 125 kg ha^{-1} seed rates using row method of sowing. The highest thousand seed weight (41.07 g) was obtained from Shorima and Lemu varieties at a seed rate of 125 kg ha^{-1} with row planting method. Similarly the highest grain yield of bread wheat (4.17 t ha^{-1}) and maximum harvest index (43.07%) were obtained from Lemu variety with 125 kg ha^{-1} seed rates combined row sowing method. Lemu variety outperformed other varieties, and the highest net benefit ETB (180,710 ETB) ha^{-1} with marginal rate of return of 1098.96% Therefore, sowing Lemu variety with row planting method in in combination with 125 kg ha^{-1} seed rate, was economically profitable that can be recommended for farmers in the study area.

Recommendation

Based on the study of this research, the following recommendations are made to improve bread wheat production and productivity in the study area. The use of appropriate sowing method, optimum seed rate and Variety were recommended to improve the production and productivity of bread wheat in the study area. Sowing Lemu variety with the combination of 125 kg ha^{-1} in row planting produce the highest grain yield rather than other varieties with the highest net benefit 180,710 ETB ha^{-1} at 1098.96% marginal rate of return. Therefore, Lemu variety by using row planting method in combination with 125 kg ha^{-1} seed rate was economically profitable and can be recommended for farmers in the study area. However, the experiment was done only in one site as well as for one season; hence it is advisable to repeat the experiment across different locations and seasons to provide more reliable recommendation for sustainable bread wheat production and productivity.

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