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Review Study on the Effect of Different Varieties Seed Size to Yields and Economic Benefits of Bread Wheat (*Triticum aestivum* L.) Crop

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Abstract: The main goal of this study is to determine the best plant population level of bread wheat crop by identifying the most economic-effective variety's seed size and to deliver an overview of wheat production management requirements in general and specifically in Ethiopia, comparing with current research trends as well as to make some recommendations on the appropriate seed rates for yields, and economic benefits of bread wheat. This paper reviewed that application of the optimum seed rate under ideal environment availability of which may help in improving yield and yield components of bread wheat. To optimize seed rate and plant density of wheat, some experiments have conducted so far across most wheat growing areas of Ethiopia. The field experiments were conducted in different times at Kulumsa Agricultural Research Center from July to November 2012. Quite similar field experiment was also conducted at Kulumsa Agricultural Research Center from June to 2018 cropping season, Three bread wheat varieties (Hidassie, Dendea and Shorima) representing different seed sizes of large, medium, small, respectively and four plant population levels of 250, 300, 350 & 400 plants m^{-2} were tested. The interaction effects of varieties seed size and plant population on grain yield showed statistically significant ($p<0.01$) variation, likewise biomass yield and straw yield indicated significant ($p<0.05$) variations. The grain yield resulted in (4.309 Ton ha^{-1}), similarly biomass yield and straw yield are (11.00 Ton ha^{-1}) and (5.28 Ton ha^{-1}) respectively, and it suggests that these traits are generally enhanced by the genetic makeups of the variety Hidassie /large seed size. Economic analysis using partial budget procedure was performed on grain yields to determine the treatment with most profitable returns. The beneficial marginal rate of return (8.50) and benefit cost ratio (8.07) was obtained from the variety Hidassie/large seed size at a plant population of 300 seeds m^{-2} followed by a marginal rate of return (9.55) and benefit cost ratio (8.05) were also recorded again from the variety Hidassie/large seed size at plant population of 250 plants m^{-2}. So the most cost-effective variety and plant population level for farmers with low cost of production and higher benefits were identified to be the variety Hidassie/large seed size at the plant population level of 300 plants m^{-2} in the rain fed cropping season is identified as low cost of production with highest benefit and can be recommended for the producers of wheat crop.

Keywords: Bread Wheat Yield, Economic Benefit, Plant Population, Seed Quality, Varieties Seed Size

1. Introduction

Bread wheat *(Triticum aestivum L.)* is the most essential cereal crop in the world [3, 69] and the main source of major food for the populations of Ethiopia. It is one of the numerous cereal crops largely grown in the highlands of Ethiopia and it produced largely in the southeast, central and northwest parts of the country. Trivial amount of bread wheat is also produced in the rest of the south and north regions of the country. Its production is highly concentrated between the latitudes of 30° and 60°N, and 27° to 40°S and within the temperature range of 3°C to 32°C [7].

Bread wheat is an important cool weather crop grown predominantly in the Ethiopian highlands at optimum altitude

ranging from 1000 to 2300 meters above sea level. Ethiopia is the largest wheat producer in Sub-Saharan Africa and bread wheat is the major cereal crops in the Ethiopian highlands, which range between 6 and 160N, 35 and 420E and 1500 to 2800 m. At national level, during 2015/16, cropping season 1,664,564.62 ha, of land was covered by bread wheat and durum wheat and producing 42192572.23 metric tons [54]. Presently at the national level about 1,747,939.31 ha of land is covered by durum and bread wheat and over 4,838,074.09 metric tons yield is produced from this land annually [22].

It is obvious that bread wheat is one of the main commodity crops known worldwide with respect to its production and economic value which requires good production and management practices. Bread wheat is used in a variety of products, but its use as flour for bread and baked goods is the most prevalent and without bread wheat baked goods, many of our popular plates would lack the appealability and character that make it preferred. One of the key reasons why bread wheat is best suited for bread making in comparison to other grains is its high gluten content. However, the quality and high yield of bread wheat production is depending on production and management practices on both field and after harvested.

Despite its importance and increased production, bread wheat yield and its quality is affected by various biotic and abiotic stresses, among which low or excess mineral nutrition, irrigation schedule or rainfall are among the major ones [19,42]. Cultivated wheat is classified into two major types; the hexaploid bread wheat (2n = 6x = 42, AABBDD) and the tetraploid durum wheat (2n = 4x = 28, AABB).

The two economically important wheat species grown in Ethiopia are durum wheat (*Triticum durum*), tetraploid of which is with a total chromosome numbers of 2n=28) and which has 4 sets of chromosomes each with a unique genome of n=7 chromosomes whereas, bread wheat (Triticum aestivum), hexaploid which is with a total chromosome numbers of 2n=42 and which has 6 sets of chromosomes each with a unique genome of n=7 chromosomes, [17].

Currently, at the global level, bread wheat accounts for 95% of all the wheat produced. Based on growth habit, wheat is classified into spring wheat and facultative/winter wheat, covering about 65 and 35% of the total global wheat production area, respectively. The flour of bread wheat is used to make French bread, Arabic bread, Chapati, biscuits, pastry products and for the production of commercial starch and gluten [14,15] Bread wheat crop has a thin root system and needs optimum and regular application of water and nutrients.

The most important characteristic of wheat gluten proteins in relation to their role in coeliac disease is the presence of protein domains comprising repetitive sequences. The domains vary in extent, but generally account for between about 30 and 50% of the protein sequence in S-rich gliadins and LMW subunits, between 75 and 85% in HMW subunits, and almost the whole protein in ω-gliadins [reviewed by Shewry *et al.,* [60]. Cropping season and soil moisture may affect the quality and yield of field crops any plants; low

moisture conditions in the soil are conducive to poor yields [61]. while excessive soil moisture results in wastage of irrigation water, nutrients leaching, and may lead to rots and poor seed quality. The crop yields varied considerably among sites and among production seasons at the same site. These variations were probably due to soil, cropping season, amount and type of nutrients available, planting date, degree of plant population and other differences in cultural practices. Mineral elements stored in seed reserves meet the nutrient demands of seedlings during their initial development and growth [63]. So far, many varieties of bread and durum wheat have been developed to satisfy the growing production demands and as a result, about 76 bread wheat and 34 durum wheat varieties have been released [54].

Significant advances in soil chemistry, crop physiology, plant nutrition, molecular biology, and information technology must be combined in this effort. Future field-oriented plant nutrition research must be of a more strategic, interdisciplinary, and quantitative nature [25].

Despite the large area cultivated for wheat, the national average yield of wheat in Ethiopia is about 2.768 metric tons ha^{-1} [23]. This is certainly lower than the world's average yield which is about 3.320 metric tons ha^{-1} [70]. The number of productive tillers is dependent on varieties and environment and strongly influenced by planting population. However, tillering capacity is increased with enough moisture availability, increasing light and optimum nitrogen availability during the vegetative phase and it depends greatly upon varieties Jemal [43]. Seed rate is one of the most important agronomic factors which need great emphasis for maximum yield of crops. High seed rate increases the competition among crops for common resource particularly water, nutrients and sunlight which result in low quality and low yield. Also, [39] reported that the use of low seed rate leads to low yield due to lesser number of plants per unit area. However, Baloch, [13]. reported lower seed rates significantly increased the number of fertile tillers produced per plant which do have pronounced effect on yield of varieties.

Besides its yield impact, sowing at a seed rate that result in optimal plant population may also reduce seed costs, lodging & disease problems which add up extra value in crop production process [56]. A number of bread wheat varieties differing in their seed size, height and maturity as well as tillering capacity have been developed in Ethiopia. However, the recommended seed rate for all the varieties being used across the country is 150 kg ha^{-1} [42]. Likewise, around the study area there is a trend by farmers to use higher plant population of seed rates for both of small and large sized bread wheat varieties (own observation). According to the research result of Zareian A, [12, 72]. seed size had a significant impact on all of measured traits with the exception of thousand seeds weight. Results indicated that number of seeds per spike significantly decreased by increasing seed size. The other traits showed significant increase by increasing seed size. Varieties seed size had significant effect on thousand seeds weight, but other traits were similar among varieties.

In view of that, it is essential to determine the optimum plant population rates for different seed sized bread wheat varieties in order to improve the production and productivity of the crop by identifying the most cost-effective varieties and profitable plant population rates with low cost of production inputs. Thus, for this review study, three recently released bread wheat varieties namely (*Hidassie, Dendea and Shorima*) representing standard categorization of seed sizes as small *(Shorima),* medium *(Dendea)* and large *(Hidassie)* with plant population rates of 250, 300, 350 and 400 plants m^{-2} were selected and tested to attain the intended objectives.

2. Body of Discussion

2.1. Historical Evolutionary Processes of Bread Wheat Crop

The process, which began some ten thousand years ago, involved the following major steps. Wild einkorn (*T.urartu*) crossed spontaneously with Goat grass 1 (*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 (*T. aestivum*) finally evolved through years of cultivation in the southern Caspian plains. 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 [33].

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 [33]. The other forms, such as *T. durum, T. turgidum* and *T. polonicum* might have originated from cultivated emmer through mutation or accumulation of mutations that reduced the toughness of the glumes to a point at which free-threshing was attained. At the tetraploid level, two main species have been recognized; *T. timopheevi* (AAGG) and *T.*

turgidum (AABB). *T. durum* belongs to the latter group. There are many known wild and cultivated species in the genus *Triticum*. However, the principal wheat's of commercial importance are *T. aestivum* and *T. durum* [8].
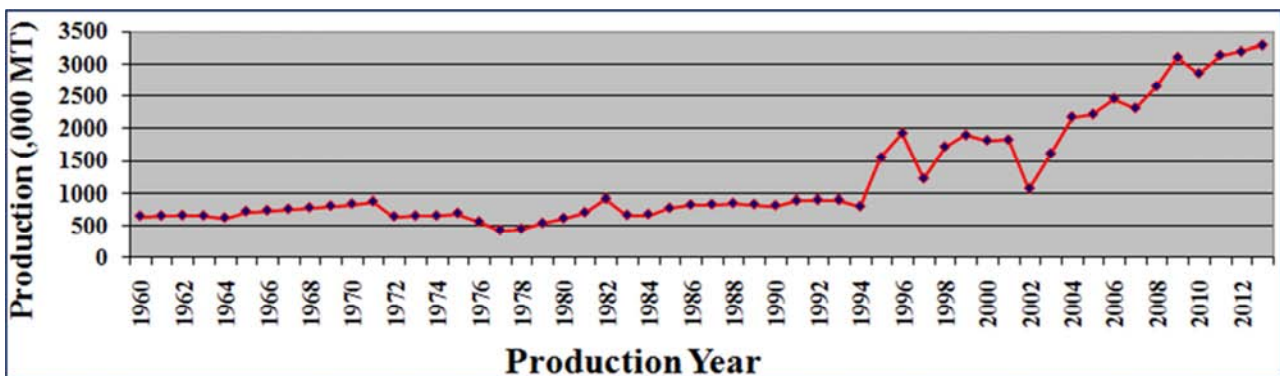
2.2. Overview of Wheat Production and Its Importance

Wheat is the leading grain and most important food crop. Its importance was derived from the properties of its gluten, a cohesive network of touch endosperm proteins that stretch with the expansion of fermenting dough, yet coagulates and holds together when heated to produce a risen loaf of bread. Only wheat, and to a lesser extent rye and triticale, have this property. It is utilized for making bread, flour confectionery products (cakes, cookies, and pretzels), unleavened bread, semolina, bulgur, and breakfast cereals. Its diversity of uses, nutritive content, and storage qualities has made wheat a stable food for more than one-third of the world's population.

2.3. Bread Wheat Production Status in Ethiopia

Ethiopia is one of the principal producers of wheat in East Africa. Wheat is one of the major cereal crops in the Ethiopian highlands, which range between 6 and 16°N, 35 and 42°E, and from 1500 to 2800 m.

At present, wheat is produced solely under rain fed conditions. It is produced mainly in the southeast, northwest and central parts of Ethiopia. Minor amount is also produced in the rest of the south and northern regions (MoANR, 2016).

At the national level presently, 1,664,564.62 million ha of land is covered by bread & durum wheat and over 42,192.57 metric tons yield is produced from this land annually and recently-released bread wheat cultivars are highly responsive to improved management systems relative to older wheat lines. Its production is increasing rapidly due to both a high local demand, and the availability of high-yielding, input-responsive cultivars adapted to heterogeneous environmental conditions [22]. Area coverage of bread wheat has substantially expanded mainly by replacing unimproved, input non-responsive traditional cereal crops such as teff *(Eragrostis Teff),* durum wheat *(T. Durum)* and barley *(Hordeum vulgare)* (MoANR, 2016).

Source: USDA, http://www.indexmundi.com/

Figure 1. *The national average yield Status of wheat production in Ethiopia from the year 1960 - 2012 GC.*
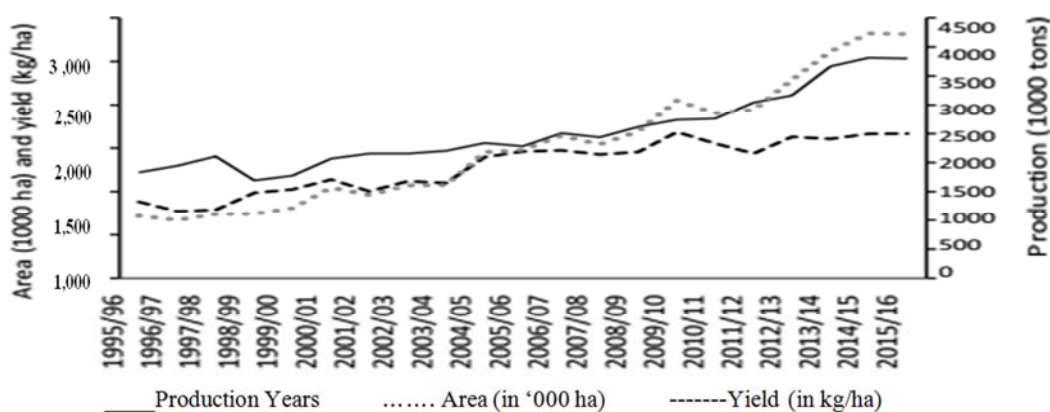
According to the [70]. study reports on the earlier bread wheat research and grain yield status, Ethiopia is the largest bread wheat producer in sub-Saharan Africa with about 0.75 million ha of bread wheat and durum wheat. Bread wheat is one of the major cereal crops in the Ethiopian highlands, which range between 6 and 16°N, 35 and 42°E, from 1500 to 2800 m. Bread wheat is produced solely under rain fed conditions. About 60% of the wheat production area is covered by durum and 40% by bread wheat. Of the current total bread wheat production area, 75.5% is located in Arsi, Bale and Shewa regions. Forty-six percent of the 13 million ha classified as highly suitable for bread wheat production is located in Arsi and Shewa.

The national wheat improvement program was organized most effectively from 1967-2012 [70]. The national average yield status of bread wheat production in Ethiopia during the 1960-2012 cropping years were showed in (Figure 1).

2.4. Present Bread Wheat Production and Existing Average Yield Statistics of Ethiopia

Bread wheat is one of Ethiopia's main essential crop in terms of both production and consumption. Based on its role in the plant populations caloric intake, bread wheat is the second most important food in the country [32]. Bread wheat is grown primarily in the highlands of Ethiopia, and the two main bread wheat producing regions (Oromia and Amhara) account for approximately 85% of national bread wheat production [21].

Source: Central Statistical Agency (1995/1996-2015/2016).

Figure 2. *Wheat production, area cultivated, and yields in Ethiopia from the years (1995/1996-2015/2016).*

The fact that the bread wheat varieties investigated in the present work exhibited some contrasting physiological properties may help to evaluate the relative importance of these properties in terms of whole plant response [19].
Even though bread wheat is typically grown by smallholder farmers in Ethiopia, the country is the largest bread wheat producer in Africa south of the Sahara by a sizable margin. Bread wheat production during the 2015/2016 Meher season was 4.1 million metric tons and has been growing significantly over time (rising by an average annual growth of 7.1 percent over the last two decades) due to both area expansion and yield improvements (Figure 2).
In terms of area, bread wheat is the fourth most widely grown crop in Ethiopia, after teff, maize, and sorghum. Today, approximately 1.7 million hectares of land are devoted to bread wheat crops that a significant increase from the less than 1 million hectares planted in bread wheat in 1996, representing an annual growth rate of 3.2 percent (Figure 2). In addition, the country has increased its bread wheat yield by approximately 3.7 percent per year over the last two decades: Current bread wheat yields are roughly double the average bread wheat yields 20 years ago, implying that more than half of the growth in production since 1996 can be attributed to yield growth [32]. The amount of plants established from a given weight of seed based on the size of

seeds and the percentage of those seeds that are viable and can grow into established plants.

2.5. Importance of Bread Wheat Crop as Source of Income and Food Products

Bread wheat is not only the most important cereal crop in the world but also the major source of staple food for the peoples [51, 69]. Despite of being grown on larger area, average yield at farmers' fields is still far below than the potential.

Bread wheat is widely consumed, in the countries to meet the consumers demand for bread and other food products. This indicated that globally there is number of people who rely on wheat for a substantial part of their diet amounts to several billions. Statistics for the total volume of wheat which is consumed directly by humans as opposed to feeding livestock, for the United Kingdom indicates about one-third of the total production, approximately 5.7 m tones per annum are milled with home production. Globally there is no doubt that the number of people who rely on wheat for a substantial part of their diet amounts to several billions [6]. The high content of starch, about 60–70% of the whole grain and 65–75% of white flour, means that wheat is often considered to be little more than a source of calories, and this is certainly true for animal feed production, with high-yielding, low-protein feed varieties being supplemented by other protein-

rich crops, notably soybeans and oilseed residues.

However, despite its relatively low protein content, usually 8–15% wheat still provides as much protein for human. In general, wheat is the most widely used cereal for bread and bakery production process throughout the whole world [59, 61, 64]. Pena-Bautista, R. J., *et al*., (2017) reported that, wheat-based foods are critical for food security and nutritional security worldwide. The global wheat researchers draw attention to the predicted upcoming food crisis, as populations in developing countries expand rapidly, especially in Africa and South Asia. They note that population growth is likely to outpace yield gains in wheat and call for larger investments in wheat and other cereal crops to keep pace with future demand.

2.5.1. Effect of Varieties Seed Size on Crop Growth of Bread Wheat

Overall, seedling establishment is controlled by genetic makeup and environmental factors. Among the genetic factors are the genes expressed in the maternal parent affect seed growth and development in different ways, the genes that control seed size are expressed in the embryo during seed development, and the genes expressed in the seedling. Different seed sizes of bread wheat varieties reflect a great extent to the amount of production costs, and as such it has a significant impact on early seedling growth and development [28, 48]. The number of plants established from a given weight of seed depends on the size of the seeds and the percentage of those seeds that are viable and can grow into established plants.

The common range of wheat seed size is 25 to 50 mg and crop establishment varies between 40 and 95 percent of sown seeds depending on soil type, soil moisture, sowing depth, seed quality, diseases and insects. Considering these variables, a seed rate of 100 kg/ha could result in an established plant population that may vary up to three fold even in a drill sown crop [53]. As described by Mingsheng, [53] 100 kg/ha sown by 90 germination percent of 25 mg seed size yielded 360 seeds m^{-2} compared to 100 kg/ha sown by 60 germination percent of 50 mg seed size which yielded 120 seeds m^{-2}. The bread wheat crop sown with large sized seeds showed remarkably better agronomic performance with 95.29% germination, 96.61 cm plant height.

2.5.2. The Effect of Plant Population Rates on Crop Growth of Bread Wheat

Gafaar (2007) reported that increasing plant population rate from 200 up to 400 grains per meter square in wheat crop significantly decreased the days to 50% of heading and days to 90% of maturity. Seed rate at a rate of 100 kg ha^{-1} shown early days to heading (72.32) followed by 125 kg ha^{-1} (72.94) and 150 kg ha^{-1} (73.57) and at the highest seeding population, the increased intra-plant competition may have also contributed to the reduction in plant height [11, 18, 37].

Furthermore, Worku Awdie (2008) revealed that increasing the levels of seeding rate decreased the days to heading and days to 90% of maturity dependably. The number of seedlings emerging does not only affect total crop yield, but the size of individual plant and the graded yields, time taken

to reach maturity and uniformity of the plant at maturity [26]. Plants derived from large sized seeds appear to have greater vigour and are able to acquire a larger share of plant growth factors relative to plants derived from small sized seeds. As number of plants $acre^{-1}$ increases, each plant captures less light, which limits each plant's growth. [68].

2.5.3. The Effect of Varieties Seed Size on Grain Yield of Bread Wheat

The research results indicated significant influence of various seed sizes on grain yield [12]. Grain yield with the smallest seed size was significantly lower than other seed sizes and this reduction were 892.8 kg ha^{-1} by (16.9%) and 144.49 by (19.7%) respectively. Similar results were recorded by Stougaard, [68]. who reported that use of larger seed sizes improved grain yields by 18% and the use of small seeds yield by 16% in wheat. On the other hand, the study findings of Nik, [55]. showed that the effect of seed size on grain yield ha^{-1} 4857.10 kg ha^{-1} grain yield.

The sown with large size seed was remarkably beneficial with most promising agronomic performance (4857.10 kg ha^{-1} grain yield) as compared to small size seeds (4400.70 kg ha^{-1} grain yield).

Seed size is an important physical indicator of seed related to yield, market grade factors and harvest efficiency and important parameter, which influences the germination, growth and biomass of the nursery seedlings and that trend leads to the future crop. Kumar, [47] observed that seed size affected the seed yield significantly. Seed size was the trait that was most consistently associated with yields. Grain yield of wheat significantly increased by increasing seed size. Variation in seed size within a seed lot affected neither seedling emergence, plant fertility, nor grain yield per plot. Gan and stobbe (1995), was suggested that small seeded plants produced 2-44% less tiller grain yield than neighboring large-seeded plants.

2.5.4. The Effect of Plant Populations on Grain Yield of Bread Wheat

According to research results of Jennifer, *et al.*, (2006), in a solid bread wheat populations, grain yield was decreased due to competition between plants that induced self-regulation. His results of grain yield were mismatched with those of Hameed, [39, 41], who reported that grain yield increased as seed rate increased.

Likewise, Jemal, [43] also reported that the bread wheat varieties *Shorima* and *Kekeba* offered the highest grain yield at a seed rate of 150 kg/ha and, variety *Digalu* produced maximum yield at seed rate of 175 kg ha^{-1} as compared to 100, 125, and 200 kg ha^{-1}. The bread wheat crop sown with large sized seeds showed remarkably better agronomic performance of 6.40 tillers $plant^{-1}$, 11.44 cm spike length, 42.65 grains $spike^{-1}$, 42.80 g seed index (g), 10241 kg ha^{-1} biological yield.

Plant population rates can impact on bread wheat grain yield [66]. Highest grain yield with maximum plant population rates was also reported by Olsen, [38, 58]. In the same way, Chaudhary, [11, 18] and Arif, *et al.,* (2003)

reported that increased tillers with increase in plant population rates.

2.5.5. The Effect of Plant Populations on Grain Quality of Bread Wheat

Quality seed is one of the most essential agronomic factor which need great importance for extreme yield of crops as to the national bread wheat production can be improved [29] According to the report of Bryan, [16] and Jennifer, *et al*., [44] bread wheat quality is not reduced at higher plant population levels as protein content; kernel weight and test weight was unaffected and these outcomes are not in line with current research results. In contrast, it was stated that protein concentration declined as plant population levels and yields increased [36]. Seed quality is defined as standard of excellence in certain characteristics and/or attributes that will determine the performance of the seed when sown or stored Seed quality describes the potential performance of a seed lot. High-quality seed lots should meet minimum standards for each of these characteristics. High quality seed is the key to successful agriculture [3]. For achieving optimum growth and yield production, the basic requirement of farming is to obtain quality seed.

Good quality seed can increase yields by 5-20%. The extent of this increase is directly proportional to the quality of seed that is being sown. The seed quality is also reflected in the final growth, maturity of plants, their uniformity and stability of yield. For seed to play a catalytic role, it should reach farmers in a good quality state, i.e. high genetic purity & identity, as well as high physiological & health quality [34] If the seed lots possess high genetic purity and high germination percentage, and meets the certification standards, is said to have high quality.

In general, poorer quality seeds show low viability, reduced germination and emergence rates, poor tolerance to sub optimal conditions and low seedling growth rates. If seedling emergence is inadequate, crop yield will be reduced and in most situations no amount of efforts and expenses later on crop development can be compensated for these effects.

There is a clear relationship between plant population and yield with yield increasing asymptotically as the population increases. Plant population rates can impact on bread wheat protein quality [66]. Hence, achieving higher agronomic performance and better end-use quality requires optimizing and periodically reviewing management practices such as plant population levels.

3. The Influence of Seed Source on Crop Growth and Grain Yield of Bread Wheat

Seed source influenced growth and yield during the growing season but the response depended on seed size and variety. The source of seed is can also be important since location influences seed nutrient content. The seed source has significant effect on seedling dry weight. Alemayehu A. [4],

was reported that the number of tillers were significantly affected by main effect of variety, seed source and seed rate. Interaction effect of variety and seed source has highly significant effect on number of tillers per 1 m length. The influence of seed source on seed quality attributes, such as germination percentage, rate of germination, seedling root length and seedling fresh weight, was significant under laboratory conditions [4]. Farmers in Ethiopia can obtain seed from formal and informal sources. The formal seed source is a system composed of institutional and organizational arrangements.

The informal seed source under Ethiopian context is defined as a system of seed production and distribution along with the different actors where there is no legal certification in the process [30].

3.1. The Effect of Plant Populations on Yield Components of Bread Wheat

This outcome also in line with [18] who explained that lower plant population levels significantly increased the number of grains per spike. Khan *et al,,* [45, 46] concluded that by increasing seed rate the 1000-grains weight is reduced. These results are in analogy with the findings of earlier works of Arif *et al*., [11] who reported higher yield with seed rate of 150 kg ha^{-1}. Plant population rates can impact on wheat tillering capacity, grain yield [66].

However, in varieties that produce fewer tillers, higher plant populations compensated for reduced tiller and promoted more main stem spikes (Staggenborg, *et al.* 2003). According to the research results of Ghulam *et al.,* [37], bread wheat plant population rate has significant influence on majority of agronomic traits and bread wheat varieties sown at seed rate of 125 kg ha^{-1} significantly enhanced the grains per spike (42.93) with compared to that of sown at seed rate of 150 kg/ha (42.08) or 100 kg ha^{-1} (42.36). Increase or decrease in seed rate from 125 to 150 or 100 kg ha^{-1}, respectively did not show any significant variation in grains per a spike. Sowing at a seed rate that result in optimal plant population may reduce seed costs, lodging, and ameliorate disease problems [37]. In spite of seedling numbers and harvest index percent appeared relatively better at higher seed rate of 150 kg ha^{-1} (95.38 and 38.66%, respectively) than that of 100 kg/ha (95.35 and 38.03, respectively) & 125 kg ha^{-1} (95.21 and 38.32, respectively), the differences between them arise statistically non-significant.

Similarly, the spike length seems to be relatively high at seed rate of 125 kg ha^{-1} (12.32 cm) compared to that of at 150 (12.20 cm) and 100 kg ha^{-1} (12.16 cm), they do show statistically non-significant differences (Ghulam S, Nizamani., *et al.,* 2014).

Plant populations appeared high at higher seed rate of 150 kg ha^{-1} (104.99 m^{-2}), followed by 125 kg ha^{-1} (101.70 m^{-2}) and 100 kg ha^{-1} (97.85 m^{-2}). Grain weight, a spike length and 1000 grain weight (gm) were although high at seed rate of 125 (2.67 and 43.67 gm, respectively) but statistically similar to that of seed rate 100 kg ha^{-1} (2.66 and 43.43 g, respectively).

3.1.1. Effect of the Varieties Seed Size and Plant Population on Grain Yield of Bread Wheat

Jemal *et al.,* [43] also reported that the varieties Shorima/*small seed size/* and Kekeba/medium seed size/ gave maximum grain yield at seeding rate of 150 kg/ha and, variety Digelu/medium seed size/ produced highest yield at seeding rate of 175 kg ha^{-1} as compared to 100, 125, and 200 kg ha^{-1}. Alike with the contemporary findings of Haile, *et al.,* [38], who reported that the lowest seeding rate (100 kg ha^{-1}) resulted in a grain yield of 3851 kg ha^{-1}, which was significantly lower than the yields obtained at the other seeding rates (150 and 175 kg ha^{-1}).

In the unlike way, Worku *et al.,* [40, 71] reported that grain yield increased as seeding rate was increased from 50 to 150 and from 100 to 150 kg ha^{-1}, respectively. Furthermore, Ali *et al.,* [5] concluded that the three years' average data showed that grain yield was maximum at seeding rate of 150 kg ha^{-1} followed by 175 and 200 kg ha^{-1} as against the seeding rate of 125 kg ha^{-1}. Reseachers reported who concluded that seeding rate of 150 kg ha^{-1} produced significantly higher grain yield (4120 kg ha^{-1}) followed by 175 and 200 kg ha^{-1} seeding rates (3904 and 3785 kg ha^{-1}).

The seeding rate of 125 kg ha^{-1} produced significantly lower grain yield (3.669 tones). Another research finding by Nazir *et al.,* [57] also showed that 150 kg ha^{-1} seeding rate produced significantly the highest grain yield. In addition, higher grain yield with higher seeding rates was also reported by Olsen *et al.,* [38, 58]. The same result has also been proved by Sikander *et al.,* [62] who concluded that increasing seeding rate from 150 to 250 seeds m[-2] resulted in higher grain yield. Whereas higher seed rate of 150 kg ha^{-1} revealed remarkably least grain weight of a spike (2.57 gm) and 1000 grain weight (42.27 gm) contrast to that of 125 and 100 kg ha^{-1} seed rates [37].

However, in the economics context, highest grain yield by itself does not indicates much about production efficiency [20] and since the above mentioned grain results were not verified by partial budget analysis, the highest yield by itself cannot be recommended for farmers. It also comes out so clearly from research publications that new technologies have been studied for potential yields but comparative economic analysis has not been part of it.

3.1.2. The Effect of Large Sized Seeds on Grain Yield of Bread Wheat

Larger seeds of spring wheat produced higher yields than smaller seeds under late-sown conditions but not under optimum management conditions. In some cases, the parental environment affected the magnitude of interacted with the observed seed size effects [28].

In bread wheat, seed size not only influence emergence and establishment but also affected yield components and ultimately grain yield. Simmone, [65] reported that size of seed has a strong influence on germination as well as growth and biomass increment of a plant. Kumar *et al.,* [47] observed that seed size affected the seed yield significantly.

In similar study was reported that use of larger seed sizes improved grain yields by 18% and the use of small seeds reduced yield by 16% in wheat [68]. Stougaard *et al.,* [68] opined that 18% of increased yield could be obtained by larger seeds in wheat. Large seeds have more food storage for embryo growth and development which lead to vigorous growth of the seedling before weeds can emerge and create competition. Lima, *et al.,* [50] noted that crop growth rate at the beginning of the growth cycle was higher in plants originating from large seeds.

Khurana *et al.,* [49] who noted that seed size variations affected leaf area, large seeds producing greater leaf area. Stobbe, *et al.,* [67] reported that crops grown from large kernels consistently yielded higher than crops grown from small kernels of the same cultivar, for bread wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare*). Adejare, [2] reported that large seed size had higher seed yield compared to other medium and small sizes.

3.1.3. Effect of Medium Sized Seeds and Small Sized Seeds on Grain Yield of Bread Wheat

Abdul, *et al.,* [1] determined that wheat sown with medium size of seed and small size seed followed a simultaneous decrease in wheat production and concluded that large size seed resulted in maximum grain yield (5294.30 kg ha^{-1}) and yield decreased considerably when sowing was done with medium size and small size seed. Elliott *et al.,* [27], noted that small seeds produced seedlings with much less vigour. Dar, *et al.,* [24] have mentioned that small seeds to medium sized ones produced better germination and seedling vigor than those of bigger ones.

Smallest seed size had lowest emergence therefore, it is assumed that plants grown from small seed had less fertile tillers than those grown from large seed. Whereby, grain yield and biological yield decreased in smallest seed size. It is obvious that increase in biological yield by increasing seed size was related to higher seedling weight and weight of 100 plants were produced by larger seed sizes in wheat [68]. Adebisi, *et al.,* 2013. Reported that in tropical soybean lots with small seed size had maximum seed germination (97%) and emergence (90%) while those with large seed size produced the highest seeds (88.00) per plant, pods (54.00) per plant and seed yield (9.72 g) per plant.

3.1.4. Relationships Among Plant Populations, Grain Yield and Yield Components of Wheat

The research results of Stougaard, *et al.,* [68] demonstrate that the use of higher plant population rates and larger seed size classes both improve wheat competitive ability towards increasing economic returns.

In general, variation in the optimum plant populations was greater between seasons for a given cultivar than between varieties within seasons. The relationship among grain yield and yield components was examined at the optimum population rather than at an arbitrary plant populations at which grain yield may have been suboptimal for some varieties. Grain yields at the optimum plant populations for the various varieties were positively related to culms m[-2], spikes m[-2] and seeds m[-2]. They were not clearly related to

culm mortality (%).

Spike size (seeds spike^{-1} or spike weight) and seed size were also not clearly related to grain yield at the optimum plant populations, and it was thus postulated that the production and survival of large numbers of culms, which in turn led to large numbers of seeds per unit area, were the source of large grain yields. Some interactions were found between yield components and plant population for some cultivars that could have implications for plant breeders selecting at low plant densities. Interactions between varieties and plant populations implied that some varieties required different populations to achieve maximum yields [10]. According to the research results of Anderson, [10] the optimum plant populations at maximum grain yield varied over 30-220 plants m^{-2}, depending the cultivars seed size.

In general, variation in the optimum plant populations was greater between seasons for a given variety than between cultivars within seasons. The relationship between grain yield and yield components was examined at the optimum plant populations rather than at a random population at which grain yield may have been suboptimal for some varieties. Grain yields at the optimum plant populations for the various variety were positively related to culms m^{-2}, spikes m^{-2} and seeds m^{-2}.

Spike size, seeds spike^{-1} or spike weight and seed size were also not clearly related to grain yield at the optimum populations., and it was thus postulated that the production and survival of large numbers of culms, which in turn led to large numbers of seeds per unit area, were the source of large grain yields. Some interactions were found between yield components and plant populations for some cultivars that could have implications for plant breeders selecting at low plant densities. Interactions between varieties and plant populations implied that some varieties required different populations to achieve maximum yields in some seasons. [68].

3.1.5. Agronomic Research and Management Options for Maximizing Bread Wheat Yields

Determination of the optimal plant population rates that necessary for optimal bread wheat yield is a major agronomic goal. In recent years, agricultural growth in China has accelerated remarkably, but most of this growth has been driven by increased yield per unit area rather than by expansion of the cultivated area. N. Majnoun *et al.,* [56] Looking towards 2030, to meet the demand for grain and to feed a growing population on the available arable land, it is suggested that annual crop production should be increased to around 580 Mt and that yield must need to be increased by at least 2% annually by means of improved farming systems and application of new technology packages, [31, 53]. This would lead to substantial improvement in bread wheat crop management practices, which are currently suboptimal.

The biggest economic gains from improved technology will come most immediately from combinations of improved crops and improved agronomical practices [31]. On the other hand, wheat is grown in a wide range of environments that affect overall performance, particularly grain yield and end-use quality. The sound performance of agriculture warrants the availability of food crops. This accomplishment in agriculture does not only signify the adequate acquisition of food crops to attain food security, but also heralds a positive aspect of the economy. In regard to this, collective efforts are being geared to securing agricultural outputs of the desired level so that self reliance in food supply can be achieved and disaster caused food shortages be contained in the shortest possible time in Ethiopia [21]. There is a high demand by commercial and small-scale peasant farmers for wheat varieties with higher grain yield, the most cost-effective and better end-use quality. From the study results of Gafaar, [35] this the use of 125 kg ha^{-1} seed rate for variety Danda'a; 150 kg ha^{-1} for varieties Shorima and Kakaba and 175 kg ha^{-1} for variety Digalu were identified for good crop stand and finally the yield.

3.1.6. The Effect of Seed Size on Growth, Quality, Yield and Yield Components of Bread Wheat

According to the research result of A. Zareian *et al.,* [12] seed size had a significant impact on all of measured traits with the exception of thousand seeds weight. Results indicated that number of seeds per spike significantly decreased by increasing seed size. The other traits showed significant increase by increasing seed size. Varieties had significant effect on thousand seeds weight, but other traits were similar among varieties. This study suggested that large seed sizes were superior compared to the other seed size and wheat cultivars had similar performance regarding to the variation in seed sizes. No significant interaction was observed for all traits studied in this experiment [12].

3.1.7. Effect of Plant Populations on Growth, Quality, Yield and Yield Components of Bread Wheat

The research results of Jemal *et al.,* [43] showed that days to 50% of heading, days to 90% of physiological maturity, plant height, spike length, hectoliter weight and Harvest Index were affected highly significantly ($p < 0.01$) by the main effects of variety and plant population whereas, grain protein content was affected highly significantly ($p < 0.01$) by only variety and biomass yield was affected highly significantly ($p < 0.01$) only by the main effect of the seed rate.

Furthermore, thousand kernels weight, number of effective tillers and number of kernels per spike and grain yield were affected highly significantly ($p < 0.01$) by the interaction effects of variety and seed rate. According to the research results of Ghulam. *et al.,* [37] the use of 150 kg ha^{-1} seed rate for variety Shorima resulted in highest thousand kernels weight (39.48 g), number of kernels per spike (60.23) and grain yield (5339.3 kg ha^{-1}). From the result of this study, the use of 125 kg ha^{-1} seed rate for variety Dendea; 150 kg ha^{-1} for varieties *Shorima* and *Kekeba* and 175 kg ha^{-1} for variety *Digalu* were identified for good crop stand and finally the yield. Seed rate at a rate of 100 kg ha^{-1} revealed early days to heading (72.32) followed by 125 kg ha^{-1} (72.94) and 150 kg ha^{-1} (73.57).

3.1.8. The Farmers Need for Optimal Plant Population Rates to Reduce Their Seed Cost

Farmers need to know what optimum seed rates they should use under their conditions. They decide whether they can reduce their costs of seed through adjustment of plant population rates. Farmers also want to know how varieties influence crop establishment and plant populations [31, 53]. According to Fan *et al.,* [31, 53] the best seed rate is that which maximizes grain yield. In practice grain yield hardly changes with further increases in plant population rates once maximum yield is reached. Seed sown above that needed to reach the flat part of the curve, is money wasted. It should be around a ratio of 5:1 i.e. the cost of quality seed is five times the value of grain produced.

The economic analysis results of this study suggested that large sized varieties and quality seeds were superior as compared to the small and medium sized seeds and hence, according to Fan, [31, 53] bread wheat varieties had similar performance with regard to the dissimilarity in the varieties seed size.

2.21 Different Seed Sized Varieties that Represent about 19 Various Bread Wheat Genotypes

The three bread wheat varieties that can represent the three seeds sizes of 32.5 mg, 37.6 mg, 42.6 mg and four plant population levels of 250 plants/m^2, 300 plants/m^2, 350 plants/m^2, 400 plants/m^2 were assigned and twelve treatment arrangements of three bread wheat genotypes were tested. The selected bread wheat varieties were classified in to three broad seed sizes, namely *small, medium and large.*

Hence the varieties *Shorima, Dendea* and *Hidassie* were selected to represent the *small, medium* and *large* size seeds of bread wheat, respectively. The three varieties with different seed sizes were combined with four plant population levels. For the convenience my experiment, these different sized bread wheat varieties were assigned as main plot treatment, while four different levels of plant population were assigned as sub plot treatments. As a result, in the then of my experiment 400 seeds/ m^2 or 4,000,000 seeds/ha was the normal seed rate to be assigned as a standard check of that experiment.
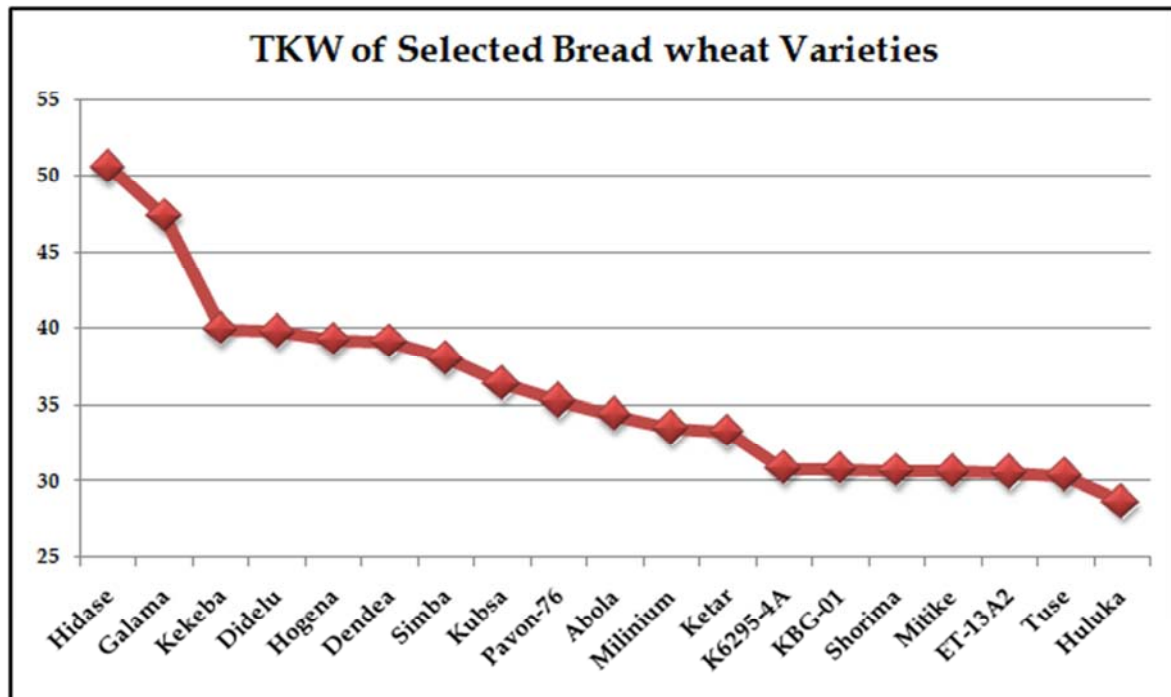

Figure 3. *Different Seed sizes of selected bred wheat varieties based on their thousand kernel weight (TKW).*

4. Economic Analysis of Bread Wheat Grain Yields

The Economic analysis results of the varieties seed size and plant populations have been indicated a consistent profitable response on grain yield of bread wheat. Relating to the partial budget analysis results, the highest net benefit value (46735 ETB ha^{-1}) was obtained from the variety *Hidassie* at a seed rate of 300 seeds m^{-2}, followed by the net benefit value (44460 ETB ha^{-1}) was obtained from the variety

Hidassie at a seed rate of 250 seeds m^{-2} and the lowest grain yield (30117 ETB ha^{-1}) was obtained from the variety *Hidassie* at seeding rate of 400 seeds m^{-2}. [7]. The results of the partial budget analysis and the economic data used in the development of the partial budget are illustrated in (Table 1).

4.1. Costs that Vary and the Inputs Price Data Collected

Data necessary for economic analysis was collected from the experiment field and from the nearest wheat producing farmers were reviewed as well. All variable costs including land preparation, planting, weed control, and harvesting costs are estimated based on the actual field prices at the time of

planting, and at vegetative growth stages as well as immediately after harvest; and assigned over the varieties and plant population levels. The variables buying costs and selling prices used for economic analysis is the 2018 and 2019 marketing costs and local market prices respectively, due to the better management conditions. The costs of NPS and N fertilizer were estimated based on the cost of NPS and Urea, respectively [7].

Dominance analysis, as recommended by CIMMYT, [20] was applied to screen treatments with higher variable costs, but lower net benefits; and dominated treatments eliminated from further considerations in Marginal analysis. The minimum acceptable rate of return was taken as 100%; and treatments with lower minimum rates of return were also removed from further analysis.

The above assigned seed prices are calculated with normal seed price of ETB 2288 per 150 kg (400 seeds m^{-2}) for one hectare, but it may become vary from this according to the varieties seed size. The total cost that vary (TVC) for lesser plant population levels was lower than the greater plant population levels. On the other hand, lowest net benefit (NBV) was scored due to the highest seed rate of 400 seeds m^{-2} which benefited about 30117 ETB ha^{-1} [7]. Relevant data to conduct preliminary assessment of economic analysis, yield levels were collected using data collecting formats that were developed to this effect. These were mainly the costs of inputs, wages, fertilizers, chemicals and the prices of outputs.

4.2. Partial Budgeting Analysis of Bread Wheat Grain Yields

In order to organize the experimental data and information about the costs and benefits of various alternative treatments, a partial budget analysis was done to determine the economic impact of various alternative treatments as compared to the farmers' practice for bread wheat production at the study area. Local market (LM) price was used to calculate the product value. The cost of labour for weeding was taken at 35.00 ETB per day.

Considering the costs that varied (cost of seed, fertilizers, chemicals and labour wage for planting, weeding and harvesting), the farmers' practice had a lower cost than the experimental method. In the partial budgeting analysis result of the present study, the costs for the different plant population levels varied according to their rates requirements being other costs were constant for each treatment. In order to recommend the present results for the study area, it is necessary to estimate the minimum rate of return acceptable to farmers or producers in the recommendation domain.

According the study results of Anbessie, [8] the highest net benefit (46735 ETB ha^{-1}) was obtained from treatment combination of variety the *Hidassie/large seed size/* with a seed rate of 300 seeds m-1, followed by net benefit (44460 ETB ha^{-1}) was obtained from the treatment combination of variety *Hidassie*/large seed size/ with a seed rate of 250 seeds/m^{-2}, while the lowest net benefit (30117 ETB/ha^{-1}) was also obtained from the combination of variety *Hidassie*/large seed size/ with a seed rate of 400 seeds/m^{-2} only in one growing season as shown on (Table 1).

4.3. Benefit to Cost Ratio Analysis (BCR)

The benefit-cost ratio analysis was used in the cost-benefit analysis in order to summarize the overall relationship between the relative costs and benefits of the proposed research project in which the BCR was expressed in monetary terms. The alternatives are not simply ranked but can be quantitatively assessed one against the other.

Table 1. *Partial Budgeting Analysis of Bread Wheat Grain Yields.*

Treatment No	Variety	Plant population ha^{-1}	Average grain yield (kg/ha)	Adjusted grain Yield (kg/ha)
1	Shorima	2500000 seeds	3930	3341
2	Shorima	3000000 seeds	4346	3694
3	Shorima	3500000 seeds	4322	3674
4	Shorima	4000000 seeds	4059	3450
5	Dendea	2500000 seeds	4134	3514
6	Dendea	3000000 seeds	4045	3438
7	Dendea	3500000 seeds	4485	3812
8	Dendea	4000000 seeds	4865	4135
9	Hidassie	2500000 seeds	4556	3873
10	Hidassie	3000000 seeds	4788	4070
11	Hidassie	3500000 seeds	3643	3097
12	Hidassie	4000000 seeds	3350	2848

Table 1. *Continued.*

Treatment No	Total costs that varied (ETB/ha)	Gross farm benefit (ETB/ha)	Net benefit value (ETB/ha)	Benefit to cost ratio (ETB)
1	5382	43433	38051	7 07
2	5656	48022	42366	7.49
3	6001	47762	41761	6.96
4	6178	44850	38672	6.26
5	5595	45682	40087	7.16
6	5931	44694	38763	6.54
7	6236	49556	43320	6.95
8	6572	53755	47183	7.18
9	5889	50349	44460	7.55

Treatment No	Total costs that varied (ETB/ha)	Gross farm benefit (ETB/ha)	Net benefit value (ETB/ha)	Benefit to cost ratio (ETB)
10	6175	52910	46735	7.57
11	6541	40261	33720	5.16
12	6907	37024	30117	4.36

Note: Cost of seed 15.25 ETB/kg; Labor Cost ETB 35/day; Field Sales price ETB 13.00/kg

The highest benefit cost ratio of (7.57) with low marginal cost and more profitable MRR (795%) was obtained from the variety *Hidassie*/large seed size/ at the use of 300 seeds m^{-2} seeding rate followed by (7.55) benefit cost ratio with the advantageous MRR (899%) was recorded from the variety *Hidassie*/large seed size/ at seeding rate of 250 seeds m^{-2} respectively (Tables 2 and 3).

Therefore, the most economical seed rates for small scale farmers of the study area with low cost of production and higher benefits in this case were 300 and 250 seeds m^{-2} seeding rates of variety *Hidassie*/large seed size/ respectively [8].

Adjusted Grain Yield Analysis of Bread Wheat (kg ha^{-1})

The adjusted yield is the average yield adjusted downward by a certain percentage to reflect the difference between the experimental yield and the yield farmers could expect from the treatment. Experimental yields, even from on-farm experiments under representative conditions, are often higher than the grain yields that farmers could expect using the same treatments [20].

There are several reasons for yield adjustment insistences and just to emphasize some key points:

4.3.1. Field Management

Researchers can often be more precise and sometimes more timely than farmers in operations such as plant spacing, fertilizer application, or weed control.

4.3.2. Plot Size

Yields estimated from small plots often overstate the yield of an entire field because of errors in the measurement of the harvested area and because the small plots tend to be more uniform than the farmers large fields.

4.3.3. Harvest Date

Researchers often harvest a crop at physiological maturity, whereas farmers may not harvest at the optimum time. Thus even when the yields of both researchers and farmers are adjusted to constant moisture content, the researchers' yield may be higher, because of fewer losses to insects, birds, rodents, ear rots, or shattering.

4.3.4. Form of Harvest

In some cases farmers' harvest methods may lead to heavier losses than result from researchers' harvest methods.

This might occur, for example, if farmers harvest their fields by machine and researchers carry out a more careful manual harvest. Unless some adjustment is made for these factors, the experimental yields will overestimate the returns that farmers are likely to get from a particular treatment [8]. One way to estimate the adjustment required is to compare yields obtained in the experimental treatment which represents farmers' practice with yields from carefully sampled check plots in the farmers' fields. Where this is not possible, it is necessary to review each of the four factors discussed earlier & assign a percentage adjustment.

4.4. Dominance Analysis of Bread Wheat Grain Yields

Dominance analysis procedure was carried to select potentially profitable treatments from the range that was tested. It was done first by listing the treatments in order of increasing costs that vary as shown on (Table 2). Any treatment that had net benefits that are less than or equal to those of a treatment with lower costs that vary is dominated. Then the dominated treatments were eliminated from further economic analysis. It led to the selection of treatments, *Hidassie*/large seed size/ at seed rate of 250 and 300 seeds m^{-2}, which ranked in equal order of the BCR respectively. The marginal rate of return for non-dominated treatments is stated in (Table 3). MRR among treatme*nts* of *the variety Hidassie* at seed rate of 300 seeds m^{-2} were lower than that of the treatments in the variety *Hidassie* at seed rate of 250 seeds m^{-2}. It was finally to in that order would give positive MRR of 795% and 899% respectively.

Table 2. *Dominance Analysis of Bread Wheat Grain Yields.*

Treatment No.	Variety/Seed Size	PPL	TVC (ETB/ha)	NBV (ETB/ha)	Dominance
1	Shorima/Small	250 seeds m^{-2}	5382	38051	
5	Dendea/Medium	250 seeds m^{-2}	5595	40087	
2	Shorima/Small	300 seeds m^{-2}	5656	42366	
9	Hidassie/Large	250 seeds m^{-2}	5889	44460	
6	Dendea/Medium	300 seeds m^{-2}	5931	38763	Dominated
3	Shorima/Small	350 seeds m^{-2}	6001	41761	Dominated
10	Hidassie/Large	300 seeds m^{-2}	6175	46735	
4	Shorima/Small	400 seeds m^{-2}	6178	38672	Dominated
7	Dendea/Medium	350 seeds m^{-2}	6236	43320	Dominated
11	Hidassie/Large	350 seeds m^{-2}	6541	33720	Dominated
8	Dendea/Medium	400 seeds m^{-2}	6572	47183	
12	Hidassie/Large	400 seeds m^{-2}	6907	30117	Dominated

Note: PPL = plant population level; TVC= total variable cost; NBV = net benefit value.

The changes to the variety *Shorima* at plant population levels of 250 seed m^{-2} is eliminated for this reason to remain with changes to the variety *Hidassie*/ at plant population levels of 250 and 300 seeds m^{-2} which gave more than 100% MRR as promising new practices for farmers under the prevailing price structure (Table 3). According CIMMYT, [20] the minimum acceptable marginal rate of return (MRR) should be 100%. As stated by CIMMYT, [20] recommendation is not necessarily based on the highest yield and even not based on the highest MRR.

Recommendation is just based on the highest net benefit cost ratio and thus, the most economically superior variety and seed rate for farmers of the study area with low cost of production and the highest net benefits were identified to be the variety *Hidassie*/large seed size/ at seeding rate of 300 seeds m^{-2} (142.00 kg ha-2). The seeding rate of 250 seeds m^{-2} (118 kg ha-2) of this variety was also profitable with the highest net benefit and recommended as 2nd option.

Table 3. Marginal Analysis Effects of Bread Wheat Grain Yield.

Treatment No	Variety/Seed Size x PPL	TVC (ETB/ha)	MC (ETB/ha)	NBV (ETB/ha)	MNB (ETB/ha)	MRR (%)
1	Shorima/Small x 250 Seeds m^{-2}	5382		38051		
5	Dendea/Medium x 250 Seeds m^{-2}	5595	213	40087	2036	956
2	Shorima/Small x 300 Seeds m^{-2}	5656	61	42366	2279	3736
9	Hidassie/Large x 250 Seeds m^{-2}	5889	233	44460	2094	899
10	Hidassie/Large x 300 Seeds m^{-2}	6175	286	46735	2275	795
8	Dendea/Medium x 400 Seeds m^{-2}	6572	397	47183	448	113

Note: ᴇ = eliminated; PPL=plant population level; TVC=total variable cost; NBV=net benefit value; MNB=marginal net benefit; MRR=marginal rate of return;

Consistent with the partial budgeting analysis results, it can be determined that the most profitable treatment was the variety *Hidassie*/large seed size/ which gave the highest benefit cost ratio of (7.57) and MRR (795%) at seed rate of 300 seeds m^{-2} whereas, alternatively the MRR of (899%) and benefit cost ratio (7.55) were attained also from the variety *Hidassie*/large seed size/ at seeding rate of 250 seeds m^{-2} as shown on (Tables 1 & 3). Therefore, the changes to the variety *Shorima*/small seed size/ at a seed rate of 250 seeds m^{-2}; Dendea/Medium seed size/ at a seed rate of 250 seeds m^{-2}, *Shorima*/Small seed size/ at a seed rate of 300 seeds m^{-2} and *Dendea*/medium seed size/ at a seed rate of 400 seeds m^{-2} are eliminated for their low benefit cost ratio and to remain with the changes to the variety *Hidassie*/large seed size/ at seed rate of 300 and 250 seeds m^{-2}. The yield of treatment 8 is higher than that of treatment 10, but the dominance analysis shows that the value of the increase in yield is not enough to compensate the increase in costs. Farmers would be better off using the lower seed rate with lower costs [7]. Based on the economic analysis Mohamed, [52] the Rolling method and seeding rate of 110 kg ha-1 had the highest net income and the lowest cost comparing other treatments.

5. Conclusion

One of the great challenges encountering Ethiopia at present is the production of sufficient food to feed the quickly increasing population growth. Getting more agricultural land-dwelling into farming is not possible in the closely inhabited regions. Improved agricultural productivity requires higher yields per unit land area, which increases the demand of improving the production and productivity of bread wheat.

Concerning varietal variations, previously studies revealed that selecting varieties which are related to the specified population and use by farmers may be a feasible option for improving bread wheat yields. Based on the result of the economic analysis, among four plant population levels the use of 300 and 250 seeds m^{-2} for the variety Hidassie /large seed size/ is superior in most of bread wheat agronomic traits. The bread wheat varieties seed size and plant population rates interaction effect showed that most economical and profitable grain yield of 4100 and 4339 kg ha^{-1} was produced at seed rate of 250 and 300 plants m^{-2} for the variety Hidassie /large seed size/ respectively. According to the partial budgeting analysis, a visible advantageous and more profitable dominance with low cost of the variety Hidassie /large seed size/ at plant population of 300 plants m^{-2} (142 kg ha^{-1}) and 250 plants m^{-2} (118 kg ha^{-1}) was found to be over the other varieties.

This shows that the variety Hidassie is genetically better in grain yield than varieties Dendea and Shorima. As a whole, significant variations in grain yield and most of agronomic parameters of bread wheat were observed due to variety seed size and plant population levels. The current study suggested that sowing bread wheat with large sized seeds such as the variety Hidassie was peculiarly beneficial with most encouraging agronomic performance. With the objective to determine the effect of seed rates and plant population rates on the grain yields and economic effects of bread wheat, the field experiments were carried out in different times at Kulumsa Agricultural Research Center from July to November 2012 & from June to November 2018 cropping seasons.

6. Recommendation

The economic analysis of the experiment was brought to select the best combination of the variety Hidassie/*large seed size*/ at a plant population rate of 300 seeds m^{-2} (142.00 kg ha^{-1}) gave the greatest grain yield (4070 kg ha^{-1}) with low cost of production and higher net benefits and recommended tentatively as 1st option for the study area. On the other hand, the variety Hidassie/large seed size/ at a plant population rate

of 250 seeds m^{-2} (118 kg ha^{-1}) gave better yield (3873 kg ha^{-1}) with a slightly additional cost rather than the primarily recommended seed rate and it was recommended as a 2nd option for the small scale farmers of the study area.

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