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Research Article

Bread Wheat Variety Demonstration and Evaluation: Empirical Evidences on Farmers Preferences, Productivity and Profitability in Central Ethiopia Region

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Abstract

The study aimed to evaluate bread wheat varieties preferred among farmers to enhance productivity and economic gains. Employing a participatory action research approach, bread wheat technologies were demonstrated and evaluated for two consecutive years in Sodo and Mareko Special districts. A total of 125 purposively selected farmers participated in 20 on-farm demonstrations. Data collection involved both quantitative and qualitative methods, including focus group discussions, key informant interviews, and grain yield measurements. Analysis included descriptive statistics (mean, standard deviation, percentage) and inferential statistics one-way analysis of variance (ANOVA) tests. Evaluation of bread wheat varieties utilized techniques like pair-wise ranking, technological gap index, and extension gap. Financial feasibility was assessed through partial budget analysis. Results showed that Dursa and Deka bread wheat varieties consistently outperformed Kakaba (check) in grain yield and technological performance, with significant differences noted in Sodo and Mareko Special districts. In both districts, Dursa and Deka exhibited a mean grain yield advantage ranging from 16.2% to 56.15% over Kakaba, respectively. In addition, the ANOVA test result also reveals there is a statistically significant difference in the grain yield of the demonstrated varieties at (P= 0.001). Furthermore, a Tukey HSD post-hoc test revealed that there is a statistically significant difference in grain yield of the varieties except between Dursa and Deka varieties with (P=0.0942). In direct matrix ranking of the varieties, farmers top ranked Deka and Dursa varieties for their higher grain yield and early maturity traits in Sodo and Mareko Special districts respectively. Moreover, a Spearman's correlation coefficient validates the reliability of farmers' assessments in predicting variety performance. Financially, Dursa demonstrates superior profitability, highlighted by a higher Marginal Rate of Return (MRR), emphasizing its financial viability for smallholder farmers in Mareko Special district. In Sodo district, as Deka exhibits a consistent superiority in yield and farmers preference While in Mareko Special district, Dursa exhibits higher yield, farmer’s preference and economic viability. Thus,, the study recommends for further dissemination and promotion of Deka and Dursa bread wheat varieties in Sodo and Mareko Special districts, respectively, than Kakaba variety by concerned bodies such as zonal and district level agriculture offices, NGO’s and seed enterprises in the study areas.

Keywords

Bread Wheat Varieties, Farmer Preferences, Technology Gap, Profitability

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1. Background

Wheat (*Triticum aestivum*) holds significant importance as a staple food crop in Ethiopia, particularly in urban areas, contributing approximately 15 percent of the country's caloric intake [1]. In addition to the grain, the straw is used as animal feed, fuel, source of income and for roof thatching. With being one of the major crops grown in Ethiopia, wheat stands second next to tef (Er agrostis tef Zucc.) and followed by maize (Zea maize) with a total production area coverage of 2.71, 2.6 and 2.44 million hectares in 2022, respectively, as reported by [2, 3]. Ethiopia holds the position of being the second-largest wheat producer in Africa, trailing only behind Egypt. The country's wheat production accounted for 21.7% of the total wheat production and 18.3% of the wheat area harvested in Africa [4]. Moreover, according to [3], wheat accounts for about 12.2% harvested area (1.9 million ha), 20.2 % total production and employment for 4.9 million subsistence smallholder farmers.

Over the last two decades, wheat production in Ethiopia has experienced substantial growth due to various government programs aimed at fostering agricultural development and ensuring food security. According to [4], the average wheat yield in Ethiopia increased from 1.21 tonnes per hectare in 1981-2000 to 1.94 tonnes per hectare in 2001-2019. Despite continuous expansion of cultivated areas and improvements in productivity, Ethiopia still faces a significant wheat yield gap compared to other leading African producers [5] and [6]. Challenges such as a lack of technical knowledge and inefficient seed and input delivery systems contribute to this gap [6]. Although there has been progress, with the average wheat yield reaching 2.97 tonnes in 2019, a considerable 261% yield gap persists [4]. Addressing food security concerns and reducing foreign currency spending on wheat imports are top priorities for the Ethiopian Government.

Despite favorable factors such as policy support and rising wheat consumption, wheat production in the study area remains below 3.1 tons per hectare [3]. This shortfall is attributed to the use of low-yielding local varieties, inadequate management practices, pest and disease challenges, and the impact of climate change and variability [6]. In Ethiopia, it is recommended to enhance access to agricultural technologies, including seeds, fertilizers, agrochemicals, and mechanization, along with early climate change mitigation measures. This strategy aims to unlock the country's potential for increasing wheat production, achieving self-sufficiency, and reducing reliance on imports. Learning from Egypt's experience, where [7] reported that 97% of the increase in wheat yield resulted from adopting new varieties, production techniques, mechanization, and modern irrigation, with the remaining percentage attributed to expanding planting areas.

The evidence suggests that the significant increase in wheat yield is credited to adoption of new varieties, production techniques, mechanization, and modern irrigation. Consequently, promoting and adopting improved wheat varieties is vital for increasing productivity. In line with this, utilizing a participatory approach enhances technology acceptance, augments farmers' knowledge, and integrates indigenous knowledge into research. The introduction of diverse varieties through participatory variety demonstration, as recognized by [8], becomes an inclusive method for communities. Particularly, the recently released Deka, Dursa, and Balcha bread wheat varieties are known for high yield and disease resistance, offer a promising opportunity. Therefore, encouraging the adoption of these varieties, alongside recommended production practices, is essential for enhancing bread wheat productivity and income of farmers in the study areas. Thereby the study aimed to demonstrate and evaluate bread wheat varieties, along with recommended practices, to farmers, evaluating their response and preference toward the demonstrated technology.

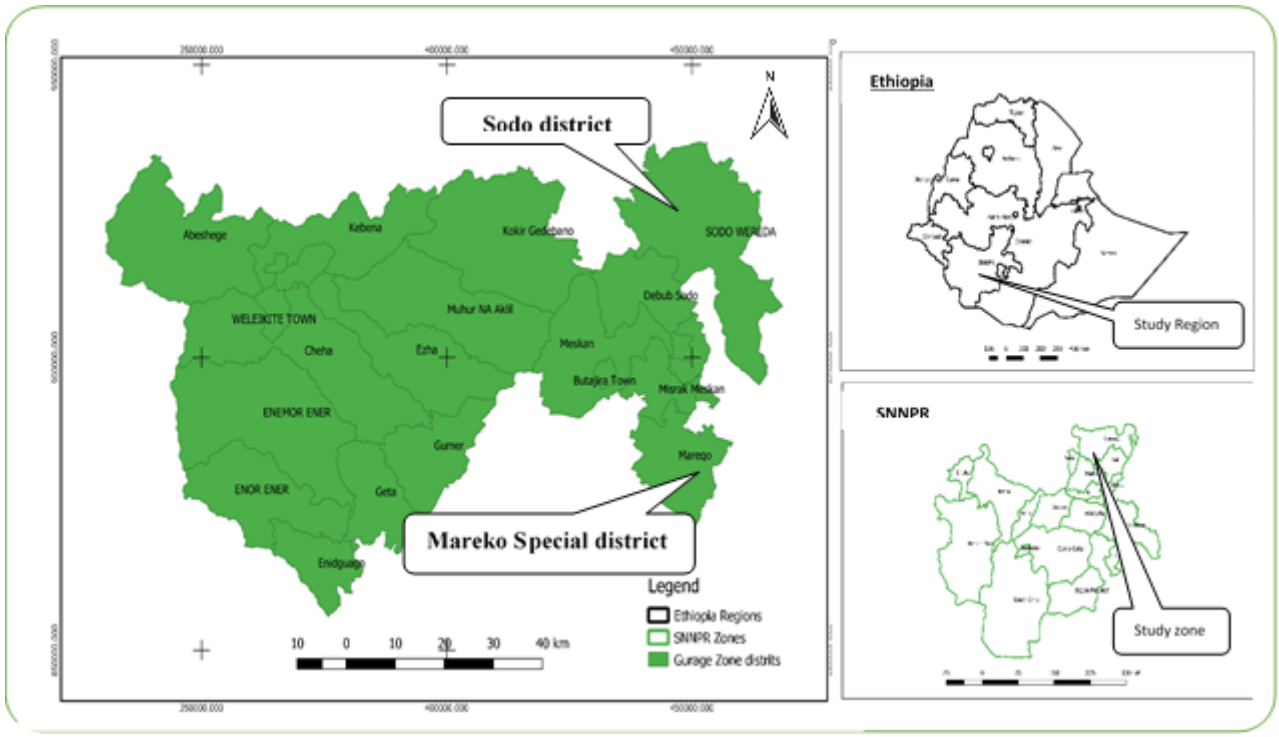
2. Materials and Methods

2.1. Description of the Study Areas

Sodo district is located in the Misrak Gurage zone of Central Ethiopia regional state. Geographically, it roughly extends from 8 °09' to 8 °45' North latitude and from 38 °37' to 38 °71' East longitude [9]. It's one of the district identified as high potential area for wheat production and commercialization in the zone by Ethiopia Agricultural Transformation Institute [10]. Agriculture is the main source of livelihood for the majority of the population in the districts, with wheat, teff, beans, and maize being the major crops grown in the area. Livestock production is also an important economic activity in the area. Sodo district, which is located to the south of Debub sodo district to south east of Mareko Special district to the west, north and the east to Oromia region predominantly characterized by mid-altitude. The altitude ranges from 1,800 to 3,040 meters above sea level, and the climate is generally characterized by a bimodal rainfall pattern, with the long rainy season occurring from June to September and the short rainy season from February to April. The mean annual rainfall in the area ranges from 800 to 1,200 millimeters. It's is divided in to two main traditional agro-climatic zones that mean Cool mid-altitude and Moist Mid-altitude [11].

Likewise, Mareko Special district is also found in Central Ethiopia regional state. The area is geographical located at latitude of 08 ̊01'53"N, longitude of 38°27‘23“ and an altitude ranges of 1,800 to 2076 meters above sea level, and the climate is generally characterized by a bimodal rainfall pattern, with the long rainy season occurring from June to September. Agriculture is the main source of livelihood for the majority of the population in the districts with wheat, maize, beans, and hot pepper being the major crops grown in the area. It's located to the north east of Sodo district to south

west of Silt'e zone to the north west of Misrak meskan, and the east by Oromia region. Despite the agricultural potential of the area, the districts face several challenges, including soil erosion, low agricultural productivity, and limited access to clean water, education, and healthcare services [12]. This study was conducted in five rural kebeles (lowest administrative units in Ethiopia) of Sodo and Mareko Special districts, which are known for their large acreage of bread wheat production in the area.



Source: [9]

Figure 1. *Map of the study areas.*

2.2. Study Approach

The study used a farmer participatory action research approach, engaging directly with farmers or affected communities to address specific issues [13]. The objective was to drive actionable change by collaboratively solving local problems. Researchers worked closely with farmers in the study area, conducting practical demonstrations and collecting data on bread wheat varieties compared to check. [14]. This participatory method fostered shared learning and knowledge creation through cooperative efforts.

Table 1. *Description of bread wheat varieties demonstrated in this study.*

Varieties' name	Year of release	Altitude (masl)	Rainfall (mm)	Grain yield (t/ha)	
				Research field	Farmers field
Deka	2018	1600-2100	500-800	3.1-5.6	2.8-
Dursa	2020	1600-2100	500-800	5.1-6.2	4.2-6.1
Balcha	2019	1600-2200	500-800	4.0-5.0	3.5-4.0
Kakaba (check)	2010	1500-2200	500-800	3.3-5.2	2.5-4.7

Source: [15]

2.3. Field Implementation Approach

In the preliminary stage, host farmers were intentionally chosen based on their enthusiasm to carry out demonstrations and the convenience of their farms for close supervision. A comprehensive training session on the production technologies of bread wheat was delivered to 117 farmers, 15 experts, and 22 development agents, as specified in Table 2. Employing a participatory approach, demonstrations were conducted in Sodo and Mareko Special districts, demonstrating improved bread wheat varieties (Deka, Dursa, and Balcha) along with checks (Kakaba). These demonstrations were conducted on 17 farmers' fields, treating each field as a replication, and spanned a duration of two years. Each demonstration plot measured 10 m * 20 m (200 m^2), with the involvement of two farmers per kebele throughout the duration of the study. Using a simple plot design, recommended practices were followed, including row planting with a 20 cm row spacing and the application of 125 kg/ha of seeds and 150 kg DAP/ha during planting. Hand weeding was performed up to three times, depending on the intensity of weed infestation.

The evaluation of demonstrated bread wheat varieties occurred during the maturity stage on host farmers' fields, with active participation from farmers, local extension workers, and researchers. Selected farmers represented the area and possessed significant experience in bread wheat production. To ensure objectivity, participating farmers established their selection criteria (such as grain yield, plant height, disease resistance and maturity date among others), individually observed entire demonstration plots, and refrained from discussing the performance of the varieties with each other during the selection process.

Table 2. *Training participants from both districts during the study period.*

Participants	Training partipants		
	Men	Women	Total
Farmers	92	25	117
Development agent	16	6	22
Experts	12	3	15
Total	120	34	154

Source: (Own computation, 2023)

2.4. Sampling Method

The study used purposive sampling to select both the study area and units, targeting districts based on criteria like total bread wheat cultivation area and suitability for the demonstrated varieties. Eight rural kebeles (four from each district) were purposively chosen for the research, considering their agro-ecological compatibility and representation of diverse conditions. This approach aimed to gain a thorough insight into bread wheat cultivation across the districts over the two-year period from 2021 to 2023. Convenience sampling was used to involve 125 farmers (92 males and 33 females) in the on-field evaluation of the demonstrated bread wheat technologies. This method prioritized practicality and accessibility, aiming to include a diverse group of farmers who could provide valuable insights. Both male and female participants were purposefully included to ensure a gender-balanced perspective, enriching the overall comprehensiveness of the study.

2.5. Method of Data Collection

The research utilized a combination of approach including focus group discussions, field observations, key informant interviews, and grain yield measurements to collect data. It covered both primary and secondary sources, examining biological, social, and economic aspects. Biological factors such as grain yield were assessed, alongside market prices and input costs such as fertilizer, labor, seed, and chemicals. The social dimension investigated the attitudes and perceptions of farmers and stakeholders. Primary data were obtained from various sources including local farmers, development agents, and experts, focusing on preferences for bread wheat varieties, desired traits, profitability, and actual yields. Additionally, secondary data sourced from local government reports and relevant published articles provided additional context and supported the primary findings.

2.6. Method of Data Analysis

The quantitative data collected underwent thorough validation for completeness before being entered into the Statistical Package for Social Science (SPSS) version 20 for analysis. Descriptive statistics such as mean, standard deviation, percentage, and frequency distribution were employed to illustrate socio-demographic characteristics. Additionally, inferential statistics like Analysis of Variance (ANOVA) were utilized to compare mean grain yield values across different varieties, followed by the Tukey test for multiple comparisons. Furthermore, financial feasibility was assessed using partial budget analysis to determine the profitability level of improved bread wheat varieties compared to the check.

The partial budget analysis method adopted from [16], is:

$$NB = GB - TC \quad (1)$$

$$MB = NBIV - NBLC \quad (2)$$

$$MC = TCIV - TCC \quad (3)$$

$$MNB = MR - MC \quad (4)$$

$$MRR = MB/MC*100\% \quad (5)$$

Where, NB= Net benefit; GB= Gross benefit; TC= Total cost; MB= Marginal benefit; MC= Marginal cost; MNB = Marginal net benefit; NBIV= net benefit of improved variety; TCIV= total cost of improved variety; TCC= total cost of the check; TR=Total revenue; MR=Marginal revenue; TVC= Total variable cost; MRR= Marginal rate of return.

On the other hand, pair wise ranking matrix was used to analyze preference of farmers towards the demonstrated bread wheat varieties. It was used to identify the variety best preferred by farmers using the following procedure. Thus, selection criteria were identified first, then ranking was given for each criterion and finally acceptability rank was determined. Data from both demonstrated improved bread wheat varieties and local check underwent analysis to evaluate extension gap, technological gap, technological index, and benefit-cost ratio, following the methodology outlined by [17].

$$\text{Technology gap} = \text{Potential yield} - \text{Demonstration yield} \quad (6)$$

$$\text{Extension gap} = \text{Demonstration yield} - \text{Farmers yield} \quad (7)$$

$$\text{Yield advantage (\%)} = \frac{yield\ of\ new\ variety - yield\ of\ local\ (standard)check}{yield\ of\ local\ (standard)\ check} \text{ X } 100 \quad (8)$$

$$\text{Technological index (\%)} = \frac{Potential\ yield - \text{Demonstration } yield}{Potential\ yield} \quad (9)$$

In the [18], Spearman's rank correlation coefficient was employed to evaluate how closely aligned farmers' preference rankings were with the actual measured attributes. This coefficient was calculated to determine the degree of correlation between the two sets of data, offering insights into the level of agreement between farmers' preferences and the observed values of the attributes. The Spearman's rank correlation coefficient was calculated as follows:

$$r_s = 1 - \frac{6 \Sigma d^2}{n(n^2-1)} \quad (10)$$

Where, d=difference in the ranks assigned to the same individual or phenomenon (actual yield ranks minus farmers preference rank in this case) and n=number of individuals or phenomena ranked (number of varieties in this case).

3. Results and Discussion

3.1. Evaluation of Bread Wheat Varieties and Technological Analysis in the Districts

Table 3 illustrates the technological analysis of bread wheat varieties across two districts and two years, showcasing variations in grain yield and mean yield advantages. In the 2021/22 season, in Sodo district, Deka exhibited a grain yield of 4.40 t/ha, with a mean yield advantage of 29.4% over Kakaba (check), while Dursa yielded 3.95 t/ha, showing a mean yield advantage of 16.2%. In contrast, Balcha had a yield of 3.82 t/ha, with a mean yield advantage of 12.35%, but a slight negative technology gap. Similarly, in Mareko Special district during the same year, Deka displayed a yield of 3.62 t/ha, with a mean yield advantage of 39.2% over Kakaba (check), whereas Dursa yielded 4.06 t/ha, showing a significant mean yield advantage of 56.15%. Balcha exhibited a yield of 3.19 t/ha, with a mean yield advantage of 22.7%, yet a positive technology gap.

Likewise in the 2022/23 season, in Sodo district, Deka demonstrated a yield of 4.49 t/ha, with a mean yield advantage of 26.8% over Kakaba (check), while Dursa yielded 4.17 t/ha, showing a mean yield advantage of 17.8%. Balcha had a yield of 3.91 t/ha, with a mean yield advantage of 10.4%, and a slightly negative technology gap. In Mareko Special district during the same year, Deka displayed a yield of 3.83 t/ha, with a mean yield advantage of 41.8% over Kakaba (check), whereas Dursa yielded 4.43 t/ha, showing a significant mean yield advantage of 64%. Balcha exhibited a yield of 3.29 t/ha, with a mean yield advantage of 21.8%, along with a positive technology gap.

Table 3. *Technological analysis of bread wheat varieties in the study areas (N=20).*

Year	Districts	Variety name	Grain yield (t/ha) Mean ±SD	Mean yield advantage (%)	Mean Technology gap (t/ha)	Technology gap index (%)
2021/22	Sodo	Deka	4.40 ±0.31	29.4	0.05	1.15
		Dursa	3.95±0.11	16.2	1.20	23.3

Year	Districts	Variety name	Grain yield (t/ha) Mean ± SD	Mean yield advantage (%)	Mean Technology gap (t/ha)	Technology gap index (%)
2022/23	Mareko Special District	Balcha	3.82 ± 0.20	12.35	-0.07	-1.86
		Kakaba (check)	3.40 ± 0.19	-	0.2	5.5
		Deka	3.62 ± 0.18	39.2	0.73	16.8
		Dursa	4.06 ± 0.13	56.15	1.09	21.2
	Sodo	Balcha	3.19 ± 0.16	22.7	0.56	14.9
		Kakaba (check)	2.60 ± 0.23	-	1	27.7
		Deka	4.49 ±0.35	26.8	-0.14	-3.22
		Dursa	4.17 ±0.22	17.8	0.98	19
		Balcha	3.91 ± 0.07	10.4	-0.16	-4.26
		Kakaba (check)	3.54 ±0.17	-	0.06	1.6
	Mareko special District	Deka	3.83 ± 0.15	41.8	0.52	11.9
		Dursa	4.43 ± 0.14	64	0.72	13.9
		Balcha	3.29 ± 0.34	21.8	0.46	12.3
		Kakaba (check)	2.70 ± 0.12	-	0.9	25

Source: (Our own computation, 2023)

The technology gap index provides insights into the efficiency of the demonstrated bread wheat varieties, indicating areas for improvement. In Sodo district, the indices for Deka and Dursa show varying levels, suggesting potential advancements in practices and technology implementation, whereas Balcha exhibits a slightly negative index, indicating a slight lag in technology utilization. In Mareko Special district, the technology gap indices suggest overall positive adoption, with Dursa showing the highest improvement potential.

3.2. Comparative Analysis of Grain Yield Among the Bread Wheat Varieties

A one way analysis of variance (ANOVA) test was carried out to examine the variation in grain yield among the demonstrated bread wheat varieties. The assessment of homogeneity of variance via Levene's test gives a non-significant result ($p < 0.057$) across different varieties. The ANOVA results revealed a significant differences among the bread wheat varieties regarding grain yield ($F(3, 76) = 34.6$, $p < 0.001$**), indicating that the selection of bread wheat variety significantly determines grain yield. The disparity among bread varieties (SS = 1453.19) exceeds the within-group variability (SS = 1063.40), emphasizing the importance of selecting suitable bread wheat varieties to enhance productivity in bread wheat cultivation in the study area.

Table 4. *Comparative analysis of demonstrated bread wheat varieties' grain yield (N=20).*

	Sum of squares	df	Mean square	F	Sig
Between groups	1453.19	3	484.39	34.6	0.001**
Within groups	1063.40	76	13.99		
Total	2516.36	79			

Source: (Our own computation, 2023)
Note: * and ** are significant association at P≤0.05 and P<0.01 respectively; the data are compared using ANOVA test

Additionally, the data presented in Table 5, obtained from the multiple comparison test of Tukey HSD, indicates signif-

icant variations in grain yield among different bread wheat varieties. Particularly, the Dursa and Deka varieties demonstrated superior performance, yielding a mean of 4.15 t/ha (SD = 0.21) and 4.09 t/ha (SD = 0.45) compared to Balcha and Kakaba, respectively.

Table 5. Multiple comparison test of the varieties grain yield.

Grain yield (t/ha)		Mean difference	Std Error	Sig	95% confidence interval	
					Lower bound	Upper bound
Deka	Dursa	-0.67	1.183	0.942	-3.77	2.43
	Balcha	5.34	1.183	0.001**	2.23	8.49
	Kakaba	9.80	1.183	0.001**	6.69	12.9
Dursa	Deka	0.67	1.183	0.942	-2.43	3.77
	Balcha	6.01	1.183	0.001**	2.90	9.11
	Kakaba	10.47	1.183	0.001**	7.36	13.52
Balcha	Deka	-5.34	1.183	0.001**	-8.44	-2.23
	Dursa	-6.01	1.183	0.001**	-9.11	-2.90
	Kakaba	4.46	1.183	0.002*	1.35	7.56
Kakaba	Deka	-9.80	1.183	0.001**	-12.9	-6.69
	Dursa	-10.47	1.183	0.001**	-13.57	-7.36
	Balcha	-4.46	1.183	0.002*	-7.56	-1.35

Source: (Our own computation, 2023)
Note: * and ** are significant association at P≤0.05 and P<0.01 respectively; the data are compared using Tukey HSD test

These findings emphasize the necessity of selecting bread wheat varieties based on their performance in specific conditions. Farmers and agricultural practitioners should consider these disparities to optimize bread wheat grain yield and enhance overall wheat productivity and food security in the area. The finding of the present study is in line with the findings of [19] and [20].

3.3. Farmers' Preferences for Traits in Selecting the Varieties in Sodo Districts

The table illustrates the bread wheat variety selection criteria deemed important by farmers in the Sodo district, with a sample size of 61 farmers. According to table 6, bread wheat grain yield (32.8%), spike length (19.7%) and number of tiller per plant (19.7%) were the primary traits prioritized by farmers. Conversely, for bread wheat varieties, maturity date (9.8%) is considered less significant by the study participants, as shown in Table 6.

Furthermore, a key informant interview further ensured that grain yield of a bread wheat is a major determinant factor in the study area. For instance, as one key informant interviewee put it "…*Deka has long spikes and holds a lot of seeds per spike so I think it give higher yield than others*…"

Table 6. Farmer's bread wheat varietal trait preference in Sodo districts (N=61).

Selection Criteria	A	B	C	D	E	F	Score	Rank
Expected grain yield (A)		B	A	A	A	A	4	1st
Spike length (B)			B	B	E	F	3	2nd
Seed color (C)				D	E	C	1	6th
Diseases tolerance (D)					D	D	3	2nd

Selection Criteria	A	B	C	D	E	F	Score	Rank
Number of tiller per plant (E)						E	3	2nd
Maturity date (F)							1	4th

Source: (Our own report, 2023)

3.4. Bread Wheat Varieties Ranked by Farmers Based on Their Selection Criteria's

Table 7. Direct matrix ranking of the varieties in the selection criteria's at Sodo (N=61).

Farmers selection criteria's	Weight	Varieties name			
		Kakaba (check)	Balcha	Deka	Dursa
Expected grain yield (A)	0.328	3 (0.328)	4 (0.328)	5 (0.328)	4 (0.328)
Spike length (B)	0.197	4 (0.197)	4 (0.197)	5 (0.197)	4 (0.197)
Seed color (C)	0.082	3 (0.082)	4 (0.082)	5 (0.082)	5 (0.082)
Diseases tolerance (D)	0.098	5 (0.098)	4 (0.098)	5(0.098)	4 (0.098)
Number of tiller per plant (E)	0.197	4 (0.197)	4 (0.197)	5 (0.197)	5 (0.197)
Maturity date (F)	0.098	5 (0.098)	5 (0.098)	4 (0.098)	5 (0.098)
Total score	1	3.78	4.29	4.90	4.37
Rank		4	3	1	2

Source: (Our own report, 2023)
Note: farmers evaluate the demonstrated bread wheat varieties based on their preferred trait using the rate 1-5; (5= very good; 4= good; 3 = moderate; 2 =poor and 1=very poor). numbers under braket represents the weight given for each criteria's by participant farmers during on farm evaluation of the varieties.

In Sodo district, farmers' preferences for bread wheat varieties were determined through a direct matrix ranking method involving 61 participants. Deka emerged as the top-ranked variety, indicating strong farmer preference, followed closely by Dursa and Balcha with ranks 2 and 3 respectively (Table 7). These findings offer valuable insights for improving bread wheat production and productivity in the region. The finding of the present study is in line with the findings [21].

Table 8. Farmer's bread wheat varietal trait preference in Mareko Special districts (N=64).

Selection Criteria	A	B	C	D	E	F	Score	Rank
Expected grain yield (A)		A	A	D	A	F	4	2nd
Spike length (B)			B	D	E	F	1	5th
Seed color (C)				D	E	F	0	6th
Diseases tolerance (D)					D	F	2	3rd
Number of tiller per plant (E)						F	2	3rd
Maturity date (F)							5	1st

Source: (Our own report, 2023)

The table illustrates the bread wheat variety selection criteria deemed important by farmers in the Mareko Special district, with a sample size of 64 farmers. According to table 8, bread wheat maturity date (32.8%), grain yield (21.8%) and Disease resistance (15.6%) were the primary traits prioritized by farmers. Conversely, for bread wheat varieties, seed color (6.2%) is considered less significant by the study participants, as shown in Table 8. Furthermore, a key informant interview further ensured that maturity date of a bread wheat is a major determinant factor in the study area. For instance, as one key informant interviewee put it "… *as our area is moisture stressed (there is rainfall shortage), we need wheat variety that is early mature and productive. Therefore, I prefer Dursa variety as it matures early and looks it holds good yield as compared to other varieties*…"

Table 9. *Direct matrix ranking of the varieties in the selection criteria's at Mareko Special district (N=64).*

Farmers selection criteria's	Weight	Varieties name			
		Kakaba (check)	Balcha	Deka	Dursa
Expected grain yield (A)	0.218	3 (0.218)	5 (0.218)	5 (0.218)	5 (0.218)
Spike length (B)	0.078	4 (0.078)	4 (0.078)	5 (0.078)	4 (0.078)
Seed color (C)	0.062	4 (0.062)	5 (0.062)	4 (0.062)	5 (0.062)
Diseases tolerance (D)	0.156	5(0.156)	5(0.156)	5(0.156)	5(0.156)
Number of tiller per plant (E)	0.156	4(0.156)	5(0.156)	5 (0.156)	5 (0.156)
Maturity date (F)	0.328	4(0.328)	4 (0.328)	3 (0.328)	5 (0.328)
Total score	1	3.93	4.59	4.28	4.92
Rank		4	2	3	1

Source: (Our own report, 2023)
Note: Farmers evaluate the demonstrated bread wheat varieties based on their preferred trait using the rate 1-5; (5= very good; 4= good; 3 = moderate; 2 =poor and 1=very poor). numbers under braket represents the weight given for each criteria's by participant farmers during on farm evaluation of the varieties.

In Mareko Special district, farmers' preferences for bread wheat varieties were determined through a direct matrix ranking method involving 64 participants. Dursa emerged as the top-ranked variety, indicating strong farmer preference, followed closely by Balcha and Deka with ranks 2 and 3 respectively (Table 9). These findings contribute valuable insights into the nuanced preferences of farmers and provide a basis for optimizing bread wheat cultivation strategies in the region. The lower the rank the variety was desirable by farmers. The finding of the present study is in line with the findings [22].

3.5. Correlation Between Farmers' Preference Rankings and the Actual Grain Yield

Table 10. *Spearman's correlation coefficient of farmers' evaluation rank with actual yield Rank.*

Varieties	Sodo district		Mareko special district	
	Farmers rank	Grain yield	Farmers rank	Grain yield
Dursa	2	2	1	1
Deka	1	1	3	2
Balcha	3	3	2	3
Kakaba (check)	4	4	4	4

Varieties	Sodo district		Mareko special district	
	Farmers rank	Grain yield	Farmers rank	Grain yield
Spearman's rank correlation coefficient (Rs)	1.00		0.800	

Source: (Our own report, 2023)

Table 10 presents Spearman's correlation coefficients for bread wheat varieties in Sodo and Mareko Special districts, revealing the relationship between farmers' rankings and actual grain yields. In Sodo district, a perfect positive correlation of 1.00 indicates precise alignment between rankings and yields, while in Mareko Special district, the coefficient of 0.800 suggests a strong positive relationship. These findings underscore the practical significance of farmers' involvement in evaluating crop technologies suited to specific localities. Similarly, the participation of farmers in evaluating crop varieties aligns with the recommendation suggested by [23].

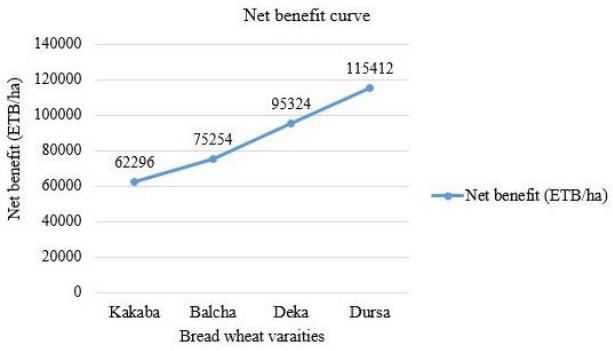
3.6. Financial Profitability of the Technologies

Table 11. *Partial budget analysis for demonstrated bread wheat varieties in Mareko Special district in 2022/23.*

	Mareko Special district			
Parameter	Kakaba (check)	Balcha	Deka	Dursa
Gross Benefit	97,200	115,200	136800	158400
Total Variable Cost	30,404	35,446	36976	38488
Total Cost	34,904	39,946	41476	42988
Net Benefit	62,296	75,254	95324	115412
Marginal Net Benefit	-	12,958	33028	53116
Marginal Variable Cost	-	5042	6572	8084
Marginal Rate of Return		2.57	5.02	6.57
Marginal Rate of Return percentage		257	502	657

Source: (Our own report, 2023)

The partial budget analysis conducted for demonstrated bread wheat varieties in Mareko Special district during the 2022/23 production year provides valuable economic insights, particularly regarding the Marginal Rate of Return (MRR) and MRR percentage for Dursa, Deka, Balcha and Kakaba varieties. Among these, Dursa demonstrates notable financial performance, boasting a Gross benefit of 158400 ETB/ha and a substantial MRR of 657%. These results emphasize the economic advantage of Dursa, making it the preferred bread wheat variety for maximizing economic gains in the study area. As a result, we recommend prioritizing the production of Dursa variety over Balcha, Deka and Kakaba in the Mareko Special district to optimize economic returns from bread wheat production.



Source: (Our own computation, 2023)

Figure 2. *Net benefit curve of the demonstrated bread wheat varieties.*

4. Conclusion and Recommendations

In conclusion, the comprehensive evaluation of bread wheat varieties and technological analyses conducted across Sodo and Mareko Special districts in the agricultural years of 2021/22 and 2022/23 yields invaluable insights into the performance and adaptability of various bread wheat varieties. Deka and Dursa consistently emerges as the preeminent variety, demonstrating both stability and superior yield performance compared to Balcah and Kakaba (check). The congruence between farmers' preferences and performance rankings underscores the imperative of selecting varieties based on specific criteria, notably grain yield and maturity date. Financially, Dursa substantiates its status as the most lucrative option, thereby emphasizing its potential for optimizing financial returns within bread wheat cultivation in Mareko Special district. These findings underscore the pivotal role of participatory decision-making among farmers in the selection of appropriate bread wheat varieties to augment productivity within the study area. Consequently, advocating for the widespread promotion of Dursa and Deka varieties among farmers within Mareko Special district and Sodo districts is strongly recommended.

Abbreviations

AMRR	Acceptable Minimum Rate of Return
CSA	Central Statistics Agency
ETB	Ethiopian Birr
GDP	Gross Domestic Product
GZAB	Gurage Zone Agriculture Bureau
MRR	Marginal Rate of Return
PAR	Participatory Action Research
SPSS	Statistical Package for Social Science
SNNPR	Southern Nations, Nationalities, and Peoples' Region

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Author Contributions

Tesfahun Fikre: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Dirshaye Hailu: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Availability of Data and Materials

The datasets used and/or analyzed during the current study will be available from the corresponding author on reasonable request.

Ethical Approval and Consent to Participate

Although no ethical approval was obtained, each participants were aware of the aim of the study and gave their consent to participate before starting the study.

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Conflicts of Interest

The authors declare no conflicts of interests.

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