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Cluster-Based Demonstration of Improved Wheat Varieties in Central Ethiopia

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ABSTRACT

Background and Objective: Wheat production in Ethiopia is constrained by low productivity, limited access to improved varieties, and insufficient agronomic practices. To address these issues, a cluster-based large-scale demonstration and popularization of improved wheat varieties was conducted in the Silte and Gurage zones. The study aimed to promote high-yielding wheat varieties with full agronomic packages, strengthen stakeholder linkages, and evaluate the yield performance of improved wheat varieties under farmers' field conditions. **Materials and Methods:** The study was carried out in four districts: Misrak Azernet and Worabe (Silte zone), and Endegagn and Debub Sodo (Gurage zone), selected based on their bread wheat production potential and participation in the FSRP program. Kekeba and Wane wheat varieties were used based on agro-ecological suitability. Participatory training and a field day were organized. Descriptive statistics were applied to compare wheat yields across sites, reporting means and standard deviation means were compared at 5% level of significance. **Results:** The average wheat yields were 47.2 q/ha (SD = 8.84) in Misrak Azernet, 32.31 q/ha (SD = 8.56) in Worabe, 33.13 q/ha (SD = 6.33) in Endegagn, and 31.5 q/ha (SD = 5.8) in Debub Sodo. These results surpassed both the national average and respective district yields. The kekeba and wane varieties showed promising performance under cluster-based management with recommended agronomic practices. **Conclusion:** The cluster-based demonstration approach effectively enhanced wheat productivity beyond district and national averages. Scaling up the use of improved varieties with full agronomic packages through extension systems is recommended. This approach can support farmers in improving wheat yield and income, contributing to food security and rural livelihoods.

KEYWORDS

Improved wheat varieties, cluster-based demonstration, agronomic practices, silte and gurage zones, wheat productivity, Ethiopia

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the internationally produced and marketed cereal crops, accounting for 15% of the total planting area of cereal crops worldwide[1]. It is one of the most important food crops that have potential impact on food security and is the second most produced grain after maize in the world[2,3]. It is also the most commonly used cereal in the bread and bakery production process around the world[4,5]. Similarly, it serves as a primary source of food and income for millions of smallholder farmers.

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China, India, and Russia are the world's top wheat producers, with Ethiopia being the largest in Sub-Saharan Africa[6]. It is a key industrial and food grain, ranking second among the most important cereal crops in the world after rice, and is traded internationally[7]. In terms of production and consumption, it is one of Ethiopia's most important crops. In terms of the population's caloric intake, wheat ranks second in the country, after maize[6].

Ethiopia is Africa's second-largest wheat producer, after South Africa, in terms of both total wheat area coverage and production[8]. The Oromia, Amhara, South, and Tigray regional states are the primary wheat producers. There are 4.7 million wheat farmers in Ethiopia. 78% of them live in the Oromia and Amhara areas. The Southern Nations, Nationalities, and Peoples (SNNP) region accounts for 13 percent, whereas Tigray accounts for merely 8%. Other parts of the country account for less than 1% of wheat farmers[9]. Wheat cultivation is currently Ethiopia's major goal, both as a source of food for people and as a source of revenue for farmers[10]. Ethiopia is the only nation in Sub-Saharan Africa where more than 70% of the country's consumption needs are satisfied by smallholder wheat production[11]. In terms of both total production and total area planted, Ethiopia is among the world's top producers of wheat[9,12]. In Ethiopia, wheat comes in third place after maize and TEF in terms of overall production and fourth in terms of area covered after TEF, maize, and sorghum[9]. Ethiopia's agricultural system accounts for 46% of total national production and employs 85% of the population[13]. It generates 75% of the value of the exported commodity. Smallholders account for 96% of all farmed land[14].

Wheat is not only the most important cereal crop in the world but also the main source of staple food for the peoples[15]. Regardless of being grown on a larger area, the average yield at farmers' fields is still far below the potential[15]. Since 1958, the Ministry of Agriculture (MOA), higher education institutions such as Alemaya University, and agricultural research institutes have mostly undertaken demonstrations of wheat technology. However, the production and productivity of the crop at the subsistence farmer level are still minimal and unable to satisfy the food security requirements of agricultural families. The low dissemination of improved and more productive varieties is among the factors that contributed to the lower productivity of the crop. In recent years, different adaptation and demonstration activities have been conducted at different locations and agro-ecological areas, which are the mandate areas of the Central Ethiopia Agricultural Research Institute. Worabe Agricultural Research Centre, which is one of the centers under the Central Ethiopia Agricultural Research Institute, has conducted different activities related to wheat adaptation and demonstration research endeavors.

Smallholder farmers in developing nations such as Ethiopia have numerous challenges, including insufficient economies of scale, limited access to resources, and market inefficiencies[16,17]. Thus, in order to increase agricultural production and productivity and transition from subsistence farming to commercialization, smallholder farmers require better access to technology, infrastructure, and markets, as well as improved technical efficiency[18]. Various demonstration activities have been conducted on different wheat varieties, like "wane" and "kekeba" varieties, at different mandate areas of the center. However, the dissemination of improved wheat varieties that farmers prefer is very minimal. This raises the need to conduct further cluster-based large-scale demonstrations of improved wheat varieties. Therefore, it is crucial to engage farmers and other stakeholders in participatory demonstration, promotion, and popularization of enhanced bread wheat technologies in order to familiarize farming communities with the varieties. The objectives of the study were to increase the production and productivity of improved wheat; to develop awareness among farmers and stakeholders on the improved wheat production technology and to assess farmers' perception and feedback towards the technology in the demonstration area.

MATERIAL AND METHODS

Site and farmer selection: The study was carried out in the 2023 main cropping season (From June to November). Four representative districts were selected from the two zones on the basis of EFSRP beneficiary districts. Accordingly, two districts (Misrak Azernet and Worabe town administration) from the zone and two districts (Sodo and Endegagn) from the Gurage zone were selected due to their potential for bread wheat production and the high demand for the crop. From each district, one representative, Keble, was also selected purposively as a demonstration site of the varieties based on their accessibility and potential. From each of the three kebeles, 20 ha of clustered land were selected, and 10 ha of land were selected from Albazer kebele (Table 1).

Farmers were selected purposively on the basis of the availability of sufficient wheat farmland, initiatives to implement activities, good field management, and willingness to explain the technologies to others. These criteria were used to select the participant farmers. They shared their knowledge and skills with other farmers at the end of the demonstration. The zone and district bureau of agriculture handed over the work at the end of the demonstration.

Implementation procedures

Training and land preparation: Before implementing the activity, training for the participant farmers was given and different stakeholders participated at each wheat cluster site. All the stakeholders from the selected Kebele, in collaboration with the District Agriculture office, were involved in the training. Moreover, Kebeles Development Agents and District-level experts participated in the training. A 32, 34, 88, and 34 participants were trained at Misrak Azernet, Worabe town, Endegn and Debub Sodo districts, respectively (Table 2). A total of 188 stakeholders participated at all four wheat demonstration sites (Table 2). The training focused on the performance of the provided wheat variety, its productivity, and wheat agronomic practices from land preparation to postharvest handling. The main aim of training was to create awareness among farmers, development agents and, district-level experts, and participant farmers on wheat clustering technology.

During this time, farmers' land preparation was checked, and farmers were organized by FREG (Farmers' Research Extension Group) and well-trained on agronomic practices of the crop. Each demonstration site has one FREG. The groups assigned their leaders, and they talked together on different issues and worked in close relationships with researchers and development agents. Improved seed was delivered to farmers from Worabe Agricultural Research Center in collaboration with the District Agriculture office.

Table 1: Number of selected farmers at each wheat demonstration site

District/woreda	Kebele	Male	Female	Total	Area (ha)
Ms/azernet	Mehal adazer	16	4	20	20
Worabe town	Albazer	14	2	16	10
Endegagn	Shorko	0	24	24	20
Debub sodo	Adila chelelek	15	3	18	20
Sub total		45	33	78	70

Table 2: Number of participants during training

	Number of participants												
	Farmers			Kebele das			Researchers			Woreda agri-expert and leaders			
District	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Total
Ms/azernet	20	12	22	2	0	2	4	0	4	3	1	4	32
Worabe town	22	6	28	1	1	2	3	0	3	1	0	1	34
Endegagn	50	26	76	3	1	4	3	0	3	4	1	5	88
Debub sodo	20	5	25	1	2	4	3	0	3	2	0	2	34
Sub total	112	49	151	7	4	12	13	0	13	10	2	12	188

Agronomic practices and inputs: Demonstration is the way of providing farmers with experiment showing how the new variety, technology and methods can be implemented and utilized to bring positive changes on farmers[19]. The wheat variety applied in Misrak Azernet District, Worabe town and Debub Sodo district was the Kekeba variety, and in Endegagn district the wane variety was used which are currently productive and high yielding at the recommended agroecology. Before sowing, the farmers prepared their land appropriately, and row planting of wheat was planted. The technology package, 100 kg/ha seeds, 100 kg/ha NPS, 125 kg/ha urea, and other fungicide and herbicide chemicals (e.g., Palas, wugzal and 2-4D) were applied according to scientific recommendations. Lime was applied at Misrak azernet cluster site before sowing to reduce soil acidity. All agronomic management practices, from land preparation to wheat harvesting, were performed accordingly.

Method of data collection: All the data were collected via appropriate data collection methods, such as focus group discussions (FGDs), direct field observations, and measurements. The yield data were measured by using a 2×2 m quadrant replicated 3 times at each farmer's field, measured in kilograms, and then converted to quintals per hectare. The total number of participant farmers, number of DAs, and other stakeholders were recorded during training and field days. The feedback data was collected through interviews. Based on the principles of research ethics, here is a statement that addresses the need for consent from participants in interviews during training and field days.

Ethical statement: Before data collection through interviews, all participants (farmers, developmental agents, and other stakeholders) were fully informed about the purpose of the study, the nature of their involvement, and how the data would be used. They were assured that their participation was completely voluntary and that they could decline to answer any question or withdraw from the interview at any time without penalty or prejudice. Informed consent was obtained from all participants, ensuring they understood their rights and the confidentiality of their responses.

Data analysis: The collected data were analyzed using descriptive statistics such as the maximum, minimum, average and percentages, and by using SPSS Version 23.0. The means were compared at 5% level of significance. Additionally, farmers' perceptions and feedback from other stakeholders were analyzed using perception scores.

RESULTS AND DISCUSSION

Grain yield performances: The sample yield was taken from ten representative farmers in each district and calculated to estimate the yield of the varieties. Hence, the average grain yield is presented below (Fig. 1). The descriptive statistics revealed that the average yields of wheat were 47.2, 32.31, 33.13, and 31.5 quintals per hectare in the Misrak Azernet, Worabe town administration, Endegagn, and Debub Sodo districts, respectively (Fig. 1). The yields obtained at each cluster site were greater than the national average yield (3.1 ton/ha)[20] and district productivity. This was due to a better clustering approach with the best agronomic management. The results of the demonstration showed that using recommended full packages for agricultural technology could increase the production and productivity of farmers[21,22]. The highest yield obtained at the Misrak Azernet demonstration site might be due to the effect of liming and farmers' best agronomic practices[23].

Farmers' perceptions: Farmers have a wide range of knowledge, but lack statistical tools to test the hypothesis and a control treatment for comparison. A 20 participants tended to believe what they perceived at each demonstration site. Likert scales are rating scales with some "anchors" that can be numerically or verbally displayed to allow measurements of a given item or question. Agreement (5 points): Very poor, poor, medium, good, and very good. Farmers were asked to rank each technology attribute from 1 to 5, where 1 = very poor, 2 = poor, 3 = medium, 4 = good, and 5 = very good[24]. At the Misrak Azernet district demonstration site, the overall average score was 4.23 (Table 3). The overall

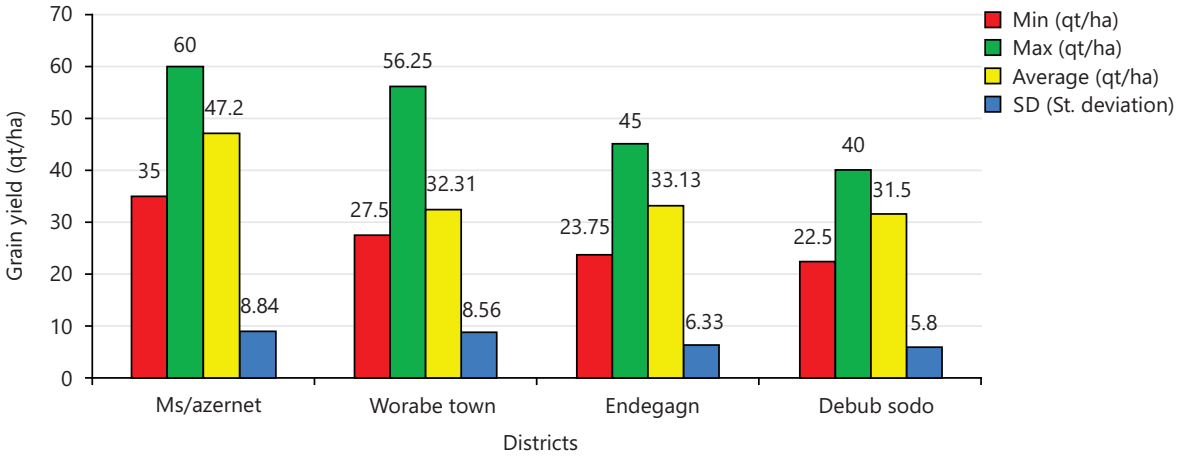

Fig. 1: Wheat cluster yield data across all districts

NB:-One quintal is equal to one hundred kilograms and -Ten farmer fields were used to measure wheat sample yield

Table 3: Farmers' perceptions on improved wheat (*kekeba* variety) attributes in the Misrak Azernet district, at the mehal adazer kebele

		Misrak Azernet District at the mehal adazer kebele (N = 20)		
No	Criteria	Average score	In percent (%)	Rank
1	Early maturity	5	100	1st
2	Disease resistance	4.5	90	3rd
3	Spike length	3.6	72	9th
4	plant height	3.8	76	8th
5	seeds per spike	4	80	6th
6	Lodging resistance	4.5	90	3rd
7	Straw-biomass	3.4	68	10th
8	Seed size	4	80	6th
9	Market demand	4.5	90	3rd
10	Grain yield	5	100	1st
Total average		4.23	84.6	

The perception of demonstrated technology was based on the desired criteria, such as plant height, disease resistance, spike length, number of seeds per spike, plant height, seed size, early maturity, and marketability

average score of wheat (Kekeba variety) was good. This means that farmers select the optimal technology. Among those traits, early maturity and grain yield were ranked first. These two attributes are given very good scores. These findings indicated that the clustered wheat at the Misrak azernet demonstration site presented a relatively high grain yield and early maturation.

At the Endegagn demonstration site, the overall average score was 4.08 (Table 4). According to the overall average score of wheat (wane variety), it was good. This means that farmers select the optimal technology. Among those traits, disease resistance and grain yield were ranked first. These two attributes are given very good scores. This finding indicated that the clustered wheat at the *Endegagn* demonstration site in the provided variety was a disease-resistant/tolerant variety with a relatively high grain yield.

Field day: The field day was organized on October, 22, 2023, at Misrak Azernet district at the Mehal Adazer kebele location to involve key stakeholders and enhance better linkages among relevant actors (Fig. 2). Thus, to demonstrate the technology, field days were arranged, and all concerned stakeholders were invited at the end of the days. At the maturity stage of the wheat, a field day was organized by inviting different stakeholders. Accordingly, 135 males, 44 females, and 179 participants from different disciplines and sectors participated. More than 86 individuals participated in the field day event, 36 of whom were female farmers (Table 5). The field day program included a visit to the fields, in-depth discussions about the activities, and reflections from farmers and stakeholders regarding the performance

Fig. 2: Field day at misrak azernet district at the mehal adazer kebele location

Table 4: Farmers' perceptions on improved wheat (wane variety) in the Endegagn district at the Shorko kebele location

		Eendegagn District (wane variety) (N=20)		
No	Criteria	Average score	In percent (%)	Rank
1	Early maturity	4.5	90	3
2	Disease resistance	4.6	92	1
3	Spike length	3.3	66	10
4	plant height	3.6	72	8
5	seeds per spike	3.8	76	7
6	Lodging resistance	4.5	90	3
7	Straw-biomass	3.4	68	9
8	Seed size	4	80	6
9	Market demand	4.5	90	3
10	Grain yield	4.6	92	1
Total average		4.08	81.6	

The perception of demonstrated technology was based on the desired criteria, such as plant height, disease resistance, and spike length, number of seeds per spike, plant height, seed size, early maturity, and marketability

Table 5: List of field day participants in misrak azernet district cluster site

Participant	Male	Female	Total
SARI management and ATTC coordinator, FSRP coordinator	8	-	8
Regional agricultural experts	2	-	2
Worabe ARC management and ATTC Researchers, and other work process researchers	18	3	21
Worabe ARC finance experts	3	-	3
Silte zone and woreda level managers (Mesirak azernet and worabe town administration)	10	3	13
DAs from ms. azernet woreda in to kebeles	6	2	8
Silte zone communication experts	2	-	2
Number of participant farmers	86	36	132
Total	135	44	179

of the "*Kekeba*" variety. Discussion sessions and result communication forums were also organized. Feedback assessment of farmers' perceptions of the performance of the technologies was also performed. Furthermore, the participants were actively discussed and established plans regarding the seed exchange system, seed collection, and marketing.

Farmers' reflections and opinions during the field day: During the field day, farmers said, "The performance of the crop was interesting, so we will continue to use this variety. The farmers reported that the improved seeds provided were disease-resistant/tolerant and high-yielding. They also said that they have wheat not only for home consumption but also for the Market. Before these years, they were afraid of risk, and they learned about how, when, and for what purpose to produce wheat. As farmers reported, the provided variety has potential in terms of grain yield and disease resistance, and its early maturity is selective.

Lessons learned: Researchers transfer scientific knowledge about the full packages of the technology, and again, farmers share their indigenous knowledge with researchers. On the basis of the data collected from farmers through interviews, they reported that merging several small farms in clusters (many farmers and

a large size of land) provides small landholding farmers with an opportunity to obtain good profits for their produce. Strong integration among stakeholders (follow-up from Zone, District, center, and CEARI) and timely availability of sufficient input are better platforms for technology transfer, and the cluster is effective. They also reported that the demonstration provided better opportunities to use full packages, i.e., fertilizer, seed rate, row planting, and chemical application, to obtain better yields, which helps farmers receive a better knowledge of the commodity and opens doors for farmers to work together and share ideas and skills that they inquire from researchers and extension. They also reported that the demonstration helped them share seeds from neighboring farmers (farmer-farmer seed sharing) in FRG and helped farmers share ideas to work, weed, and apply chemicals on time.

Feedback given: Farmers and other stakeholders have shown positive responses and feedback to the demonstrated wheat technology and the demonstration strategy. In all the wheat cluster sites they reported, the improved wheat varieties were productive, adaptive, and disease-resistant, and had relatively high yields because they would continue to use the varieties if they had access to them. During Misrak Azernet wheat field days, farmers appreciate researchers and different stakeholders who support them, and they ask the researchers to obtain a combiner harvester and recommend fungicide chemicals for the next year to maximize their yield. Similarly, other stakeholders also showed positive responses and feedback to the technology and the demonstration strategy. On the other hand, the Zone Agricultural office, the WAR Center director, and the FSRP leaders appreciated the farmers' approach and collaborative agronomic practices, and they gave feedback to develop their approach for the next few years. District experts and developmental agents also explained that this approach encourages research extension linkages to be strengthened. It provides a way to communicate with each other and exchange information from research to extension.

CONCLUSION

Cluster-based large-scale demonstration and popularization of improved bread wheat technologies with their full packages was demonstrated in Silte and Gurage zones across four different districts. In all districts, a total of 74 farmers participated, and 70 ha of land were included in the cluster. A 70 Quintals of improved seed were delivered from Worabe Agricultural Research Center and distributed to farmers in collaboration with Keble development agents. Field evaluation was performed at different times at different crop stages to evaluate farmers' perceptions of the technologies. Farmers gave their feedback on the crop performances, package components, and comparisons between what they previously used. The crop performed well in almost all the farmers' fields. Yields were recorded at each cluster site from the fields of the 10 farmers. The yields obtained at each cluster site were greater than the national average yield and district productivity. The yield obtained at the Misrak Azernet site was greater than that at the other demonstration sites. Thus, it is recommended that it is better to disseminate and address wide areas of the community through extension systems with their full packages, including agronomic practices. Farmers should use wheat in a clustered form for better management to increase their wheat production and generate more income for their livelihood. Concerned bodies are expected to disseminate those varieties further to produce quality seeds and address potential areas. Integration work of different stakeholders could minimize effort duplication. Therefore, attention should be given to integration works by concerned bodies.

SIGNIFICANCE STATEMENT

This study addressed an essential need in agricultural growth through examining the on-farm performance of high-yielding Kekeba and Wane varieties of wheat in various locales. The study identified the benefits of better wheat varieties by employing clustering approaches in larger areas. This comprehensive demonstration is critical for accelerating the dissemination of new agricultural technologies, expanding the productivity and economic importance of smallholder farmers in the area, and promoting sustainable wheat production. This approach allows the researchers to analyze the performance of new varieties under a variety of circumstances and agricultural practices. It enables direct feedback loops from farmers.

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