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Seed-Business Oriented Demonstration Trials: An Efficient Option to Promote Tef (*Eragrostis tef*) Varieties

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*ኢትዮጵያ ውስጥ ጤፍ (**Eragrostis tef**) ከ6.5 ሚሊዮን በሚበልጡ አነስተኛ አርሶ አደሮች ይመረታል፡፡ ሆኖም ግን የተሻሻሉ ቴክኖሎጂዎችና የምርጥ ዘር ተጠቃሚነት ውስን በመሆኑ የሰብሉ ምርታማነት ዝቅተኛ እንደሆነ ቀጥሏል፡፡ ስለሆነም አነስተኛ አርሶ አደሮች ጥራቱን ለጠበቀ የጤፍ አራቢ ዘር ያላቸውን ተደራሽነት ለመጨመር ዓላማ ያደረገ ጥናት በ254 መሪ አርሶ አደሮች ማሳ ላይ ተካሂዷል፡፡ በጥናቱም በቅርብ ጊዜ የተለቀቁ ሦስት አዳዲስ ዝርያዎች እና አንድ ቀደም ብሎ የተለቀቀ ዝርያ (ቦሰት) ተካተው ተገምግመዋል፡፡ ለእያንዳንዱ መሪ-አርሶ አደር የአራቱም ዝርያዎች ማለትም የኮራ፣ የተስፋ፣ የዳግም እና የቦሰት አራቢ ዘር ተሰጥቷል፡፡ የአራቱ ዝርያዎች የዘር ምርት ተቀራራቢ (ኮራ = 1.94፣ ተስፋ = 2.31፣ ዳግም = 2.24 እና ቦሰት = 2.36 ቶን በሄክታር) ነበር፡፡ ጥናቱ በተካሄደባቸው ወረዳዎች ያለውን የግብዓት ዋጋ እና የምርት ዋጋ እሳቤ ውስጥ ሲገባ የተገኘው አማካይ ያልተጣራ ገቢ 65,355.90 ብር በሄክታር ሲሆን አማካይ የማምረቻ ወጪው ደግሞ 26,355.52 ብር በሄክታር ነበር፡፡ ከማምረቻ ወጪዎች መካከል ለጉልበት የወጣው ወጪ ትልቁን ድርሻ ሲይዝ ከጠቅላላው ወጪ 58 በመቶ ድርሻ ነበረው፡፡ በአጠቃላይ የገቢ-ወጪ ምጣኔ 1.5 በመሆኑ የተሻሻለ የጤፍ ዝርያ ቴክኖሎጂ መጠቀም በጣም ትርፋማ እንደሆነ ጥናቱ ያመለክታል፡፡ ይህም በመሆኑ አዳዲስ የሚወጡ የጤፍ ዝርያዎችን ዘር አባዝቶ ለገበያ ማቅረብን ትኩረት ያደረገ የሰርቶ ማሳያ ስራ ቢሰራ ለአርሶ አደሮች ሳቢና አዋጭ ሆኖ ተገኝትዋል፡፡*

ጠቋሚ ቃላት፡ መሪ አርሶ አደሮች፤ የጤፍ ዝርያዎች፤ የምርጥ ዘር ምርት፤ የጤፍ ጭድ፤ የምርት ዋጋ

Abstract

*Tef (**Eragrostis tef**) is extensively cultivated by over 6.5 million smallholder farmers in Ethiopia. However, the productivity of the crop remains low mainly due to the limited use of improved technologies including seeds. In this study, three recently released and one old (as a check) tef varieties were evaluated on 254 lead farmers' fields with the main aim of increasing farmers' access to quality breed* *seeds.Each lead farmer was provided with breeder seeds of four improved tef varieties, namely Kora, Tesfa, Dagim, and Boset.The seed yield from the four tef varieties were comparable (Kora = 1.94, Tesfa = 2.31, Dagim =2.24 and Boset = 2.36 t ha^{-1}). Given the input and output prices that prevail in the selected districts, the mean revenue was 65,355.90 Birr ha^{-1} while the mean production cost was 26,355.52 Birr ha^{-1}. Among production costs, labor took for the lion's share as it contributed to 58% of the total cost. In general, with a benefit-cost ratio of 1.5, our technology is highly profitable and attractive to farmers if newly released tef varieties are disseminated in the seed-business-oriented method.*

Keywords: Lead farmers; Tef varieties; Seed yield; Tef straw; Production costs

Introduction

Demonstrating improved technology to farmers is considered as a traditional practice because it has been used in the extension program for so long that it has become a default approach. It is, of course, hard to imagine an extension system that does not feature the dissemination of improved technology without demonstration. The question is often not whether demos are necessary, but where, when, and how they are implemented (Knapp, 1903; Wright, 1926).

Demonstrations can be an efficient way of reaching many farmers, especially when they are built around a seed business-oriented production approach. They provide a useful platform for congregating and training farmers. In situations where a cascading (training of trainers) approach is used for extension outreach, demos serve as a classroom, where farmers can meet to learn about innovative practices so that they can replicate the demos on their farms. Each demo then becomes a locus for learning, seed multiplication, and dissemination thereby enabling efficient scale-out of technologies (CARE, 2015).

As explained by Mbure and Sullivan (2017), the six goals for effective demonstration are audience interest, understanding the purpose of demonstration, simplicity, repeatability, participation by observers, and satisfaction.

Farmers would not change their methods as a result of observing farms operated at public expense, but demonstrations conducted by farmers themselves on their own farms under ordinary farm conditions were the answer. What a man hears, he may doubt; what he sees, he may also doubt; but what he does, he cannot doubt (Knapp, 1903; Martin, 2008; Hancock, 2017).

Despite the diverse nature of agriculture demos, there is surprisingly limited empirical evidence regarding factors that influence their successful implementation. Although complete demonstrations require considerable time and effort, the payback comes when producers more readily adopt practices, they perceive to be appropriate under their local conditions. This is in line with the adage known as "seeing is believing". As a picture speaks a thousand words, demonstrations can communicate a rich spectrum of messages to farmers.

Moving on to practicalities, how could improve varieties needed for rural development be best promoted on the ground?In fact, well-presented and managed demonstrations can play a critical role in hastening technology adoption. However, new technologies might be adopted more readily, if the business aspect is accompanying the conventional technology demonstration. For instance, when farmers themselves sell and distribute the technology such as the seed they multiplied; fellow farmers are more likely to try it on their own farms.

From our earlier experience working with a single variety on 10 lead farmers had a limitation to make comparisons (Abate *et al*., 2017). We, thus, devised a new study including *Kora, Dagim, Tesfa,* and *Boset*(as check) varieties on 254 lead farmers between the 2016 and 2018 cropping years. The main objectives of the study were: 1) to disseminate the improved tef varieties by generating income and boosting seed for farm use; and 2) to estimate, at household-level, the yield, production cost, and revenue of tef technologies focusing on improved tef varieties.

Unlike the traditional demonstration trials, this study exhibited the performance of four tef varieties under particular sites and conditions. In brief, the seed-business-oriented demonstration trials aim to alleviate breeder seed shortage that makes small-scale farmers be dependent on the external source for their seed requirements.

Methodology

Guiding principles for demonstration work

The demonstration trials were managed by farmers themselves. Three points considered in this field demonstration study were: 1) most of the farm resources including labor and inputs were shared among the farmers; 2) the seed quality was managed by the farmers' field monitoring team, with close and regular researcher's follow-ups; and 3) the lead farmers were entered into a agreement with the researcher to manage the demonstration plots of his/her own and assist fellow farmers. The responsibilities of lead farmers and researchers are indicated in Table 1.

Table 1. Responsibilities of lead farmers and researcher in the implementation of field demonstration involving tef

Items	Responsibility	
	Lead farmer	Researcher
Improved seed		x
Fertilizer	x	
Manure	x	
Pesticides and herbicides	x	
Land	x	
Labor	x	
Overall Follow-up	x	x
Technical advice		x
Knowledge & experience sharing	x	x

Study Area

Four districts (locally known as *Woredas*) were selected for the studyin the central highlands of Ethiopia: These were, *Ada'a* and *Gimbichu* Districts from East *Shewa* Zone of *Oromia* Regional State; and *Moretna-Jirru* and *Minjar-Shenkora* Districts from North *Shewa* Zone of the *Amhara* Regional State. The four districts are major tef producing areas where 30-40% of the total area is allocated to tef cultivation. In addition, farmers in these districts have broad and long-standing experiences in tef farming. The geographical locations of the four districts are shown in Figure 1.

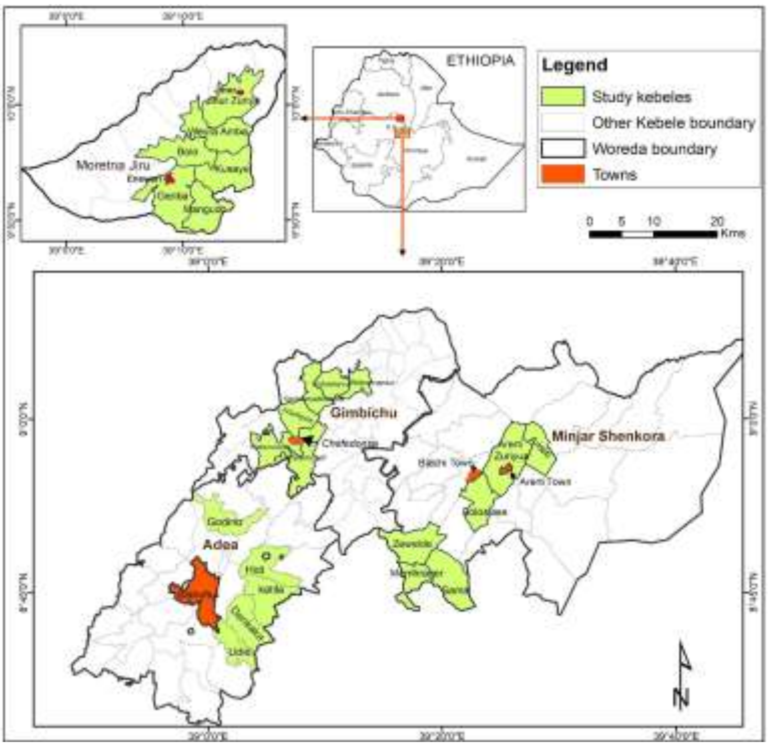

Figure 1. The location map of the study area

Design and sampling

Two hundred and fifty-four lead farmers were randomly selected from a shortlist of 580 lead farmers. The shortlist was provided by the community leaders and the local government agricultural services. The term “lead farmers” refers to smallholder farmers who are willing to test new farming technologies including improved varieties in their fields (Martin, 2008; Corps, 2014).

In each cropping season, eighty-four lead farmers were selected from each district. The selected farmers were provided with training, technical advice, and seeds of tef varieties released recently to plant on one-fourth of a hectare.To compare the results, any two varieties (*Kora* and *Tesfa* or *Dagim* and any new variety and *Bose*t (as a check) based on each farmer’s preference were planted side-by-side on the same farmer’s field. For each of the two varieties, 4-5 kg of seed was provided to each farmer. The choice of the varieties was based on the farmer’s will and request. The selected lead farmers entered into an agreement with the researcher to manage the demonstration plots of his/ her own, except for the provision of improved seeds, regular field supervision, and technical advice. Farmers individually decided on all other agronomic management practices which include frequency of plowing, time of sowing, time of hand weeding, and type, time, and rate of fertilizer application. Before the start of the actual demos, the lead farmers were given training on improved tef seed production and management practices. Moreover, except for the seed required for demonstration, the lead farmers used their own inputs and they were also responsible for managing the demonstration trials, while the researcher and the extension agent were responsible for facilitating and providing guidance. The researcher also assisted the lead farmers to ensure that the demonstrations/trials were within their capabilities by keeping field trials as simple as possible (i.e., only one to two treatments) and reflected on what the farmers are currently practicing.

Data collection and analysis

The seed yield and straw yield were collected from each plot and converted into their value in the local market. In addition, costs related to seed, fertilizer, oxen power, and labor were recorded. The data were coded and entered into the SPSS computer software package for analysis. Data were initially analyzed using descriptive statistics such as means, frequency, percentages and standard deviations. Then the seed yield was analyzed as two factors factorial experiment in Randomized Complete Block design. Districts/ *Woredas* and varieties, each at four levels, were the two factors; whereas farmers, who grew a variety within a district/*Woreda*, were considered as replications. To combine yearly data into one data set, initially each year data set was analyzed separately and the ratio of the maximum to the minimum variance, which was 1.1, was used as a criterion whether to combine the data or not. Because the number of replications was not equal, Proc GLM of SAS was used to analyze the data, and Tukey, at appropriate p-value, was applied to separate means when differences in seed yield were significant.

Combined analysis can also be applied when the lead farmers involved in the field trials have similar production sets, farming practices, and farm tools, as well as low amounts of purchased inputs other than labor, share the same support structures, and are exposed to the same technical guidance on how to manage the field trials (Atkinson and Cornwell, 1994).

Gross margin was calculated as the difference between gross revenue and variable costs. Gross revenue is the product of the total seed and straw produced and the price per unit of these products. Profit was estimated for 154 lead farmers and refers to the difference between total revenue and total costs which include the cost of seed, fertilizer, oxen power, labor. All costs and revenues were first quantified based on 0.25 ha land of each farmer, and later extrapolated to a hectare basis.

Results and Discussion

Based on the seed quality and better yield performance, only 154 host farmers out of the 254 were selected for data analysis. The selected host farmers had properly recorded the costs they outlaid and managed their fields effectively and efficiently. The plots from the remaining farmers were not selected by the farmers' field monitoring team and the researcher due to seed adulteration and improper farming practices. Seed quality either for sale or farm use was one of the elimination factors.

Moreover, the demonstration trials were managed by the farmers themselves with a close follow-up of the researcher on a regular basis. Prior to the cropping season, the data recording format was developed by the researcher and a day-long training was given to the lead farmers selected from the four *Woredas*. But when the trials were monitored and the data collection inspected, the omitted farmers did not do well and in the end, the seed produced did not meet the quality requirements to allow the lead farmers to sell to fellow farmers.

Estimates of farm inputs

Four main input types were identified in the small-scale farming system in the study districts. These were seeds of improved variety, chemicals: fertilizer and pesticide, labor and oxen inputs. The use of these inputs was neither uniform among all farmers nor constant from one cropping season to the next. While all farmers participating in the study admitted to having used all of these inputs at one time or another, some host farmers obtained the maximum attainable yields due to efficient management of available resources (land, seed, fertilizer, and labor)within the study period.

The mean rates of fertilizer application for tef were calculated to be 215.00 kg ha^{-1} NPS and 140 kg ha^{-1} urea. In many cases, the rates applied by farmers were greater than the recommendations.

When farmers were asked for the reason not applying the recommended rate, theyindicated that the fertility of their farm (plot) was too low due to lack of crop rotation. During the last 2-3 cropping years, farmers abandoned growing leguminous crops because of pest and disease problems. Secondly, farm size is diminishing from time to time and posed shortages to feed the family. Thus, farmers felt that the recommended rate could not be sufficient to provide an acceptable yield to satisfy family needs.

Farmers were trained to keep track of farm inputs they utilized on their demonstration plots. Accordingly, the seed and fertilizer rates, labor and oxen used in the demonstration trials as recorded by the farmers are indicated on Table 2.

Table 2. Extent of seeds, fertilizer, labor and oxen used in the demonstration trials as recorded by the farmers (n = 154)

Parameters	Seed (Kg ha^{-1})	Fertilizer (kg ha^{-1})		Labor (Man-hour ha^{-1})	Oxen (Oxen-hour ha^{-1})
		NPS*	Urea**		
Minimum	16.00	200	100.00	772.00	408.00
Maximum	20.00	260	200.00	956.00	504.00
Mean	18.30	215.00	140.00	854.70	459.90
St. Deviation	2.00	26.31	41.12	46.05	25.06

**NPS contains 19% nitrogen, 38% P_2O_5 and 7% Sulphur*
***Urea contains 46% nitrogen*

Estimates of yield

In each year, there were statistically significant ($p < 0.05$) differences in seed yield among varieties; whereas the effects of districts/ *Woreda*, replication (farmers) and districts by variety interactions were statistically non-significant ($p > 0.05$) (Table 3). Moreover, the combined analysis revealed that only varieties and year by *Woreda* interaction did significantly ($p < 0.05$) affect seed yield of tef. On the otherhand, the effects of replication (farmers), year, *Woreda*, year by variety interaction, *Woreda* by variety interaction, and *Woreda* by year by variety interaction were statistically ($p > 0.05$) non-significant.

It was found that in all years, the variety *Boset* gave the highest seed yield, which was followed, in decreasing order, by *Dagim*, *Tesfa*, and *Kora*. The non-significant difference in seed yield among the replicates (farmers) suggests that farmers' tef crop management practices were similar across the test *Woredas*. Since all farmers in this study were Lead Farmers who readily accept and practice advanced tef technologies, the non-significance difference in seed yield of tef among these farmers is expected. On the other hand, the non-significant difference in seed yield among the test *Woredas*, other than the age-old tef growing history of each *Woreda*, suggests that the specific test sites might have similar soil type (eg. Vertisol) and weather conditions. Also, it is interesting to note that some varieties in a *Woreda* and in a year had relatively larger standard errors of means than the others. This indicates that, although the effects of replicates (farmers) on seed yield of tef varieties was statistically non-significant, individual farmers within a *Woreda* had obtained variable amounts of seed yield.

Table 3. Seed yield of four improved tef varieties grown in four *Woredas* from 2016 to 2018

Year	*Woreda*	Seed yield in kg/ha ($\overline{X} \pm SE$)				Mean
		Boset	*Dagim*	*Kora*	*Tesfa*	
2016	Gimbichu	2460.00 ± 81.24	2600.00	2023.33 ± 67.41	2150.00 ± 50.00	2297.27 ± 77.27
	Minjar-Shenkora	2493.33 ± 46.54	2500.00 ± 57.74	1940.00 ± 63.13	2313.00 ± 56.09	2297.25 ± 46.01
	Moretna-Jirru	2513.33 ± 75.13	2286.00 ± 84.17	1846.67 ± 102.45	2311.43 ± 92.77	2217.69 ± 62.56
	Ada´a	NA	2800.00	2000.00	NA	2400.00 ± 400.00
	Mean *	2488.00^{a} ± 34.71	2408.42^{ab} ± 58.65	1928.09^{c} ± 45.10	2295.26^{b} ± 45.14	
	CV(%)	8.26				
2017	Gimbichu	2488.89 ± 111.11	2200.00 ± 0.00	NA	1984.00 ± 65.23	2295.00 ± 86.93
	Minjar-Shenkora	2500.00±100.00	2342.86 ± 84.11	2000.00	2300.00 ± 100.00	2375.00 ± 60.21
	Moretna-Jirru	2400.00 ± 46.19	2337.14 ± 113.09	2097.14 ± 49.27	1740.00 ± 60.00	2195.79 ± 64.16
	Ada´a	2400.00	2533.33 ± 133.33	1925.00 ± 72.58	2377.14 ± 46.07	2212.63 ± 70.21
	Mean *	2473.68^{a} ± 59.96	2355.79^{ab} ± 56.39	2005.00^{c} ± 45.99	2165.00^{bc} ± 67.02	
	CV(%)	9.74				
2018	Gimbichu	2380.00 ± 107.21	2270.00 ± 86.02	1800.00 ± 115.47	1992.00 ± 88.00	2157.37 ± 69.58
	Minjar-Shenkora	2291.43 ± 85.39	2400.00 ± 200.00	NA	NA	2315.56 ± 74.97
	Moretna-Jirru	2462.86 ± 121.22	2362.50 ± 58.70	2333.33 ± 176.38	2430.00 ± 10.00	2389.29 ± 47.33
	Ada´a	2472.00 ± 34.15	2396.36 ± 38.69	2100.00 ± 60.00	2323.33 ± 58.97	2386.89 ± 24.14
	Mean *	2409.33^{a} ± 42.00	2362.06^{ab} ± 33.75	2075.00^{c} ± 111.98	2212.31^{bc} ± 65.58	
	CV(%)	8.97				
	Grand mean*	2449.86^{a} ± 26.57	2372.64^{a} ± 26.44	1981.56^{c} ± 33.35	2229.38^{b} ± 33.94	
	CV(%)	9.02				

*= means followed by the same letter within a row are not statistically different at p = 0.05; means without standard errors of mean were not replicated; NA (not available) indicates that variety was not grown in that year/ *Woreda*; grand mean was derived from the combined analysis.

Within the same environment, there are three distinguished clusters of factors with which tef yield differences can be associated: the input used, management, and socio-cultural clusters. In the input cluster, the use of basic inputs such as improved seeds and fertilizers do significantly improve yields (Seufert *et al*., 2012). However, there are constraints at the farm and household levels that may have to be overcome to optimize the availability and use of farm inputs. In the farm management cluster, the method of residue management, crop rotations and the time management of field operations, and the control of pests and diseases are important in determining yield differences. In the socio-cultural clusters, the farmers' capability in making farm decisions and access to agricultural production resources are the dominant factors in bringing yield gaps. In these demonstration trials, both farmers and researchers paid close attention to estimate data on seed and straw yields through minimizing the three distinguished clusters of factors.

The area was planted, and the straw and seed yields for the four varieties were comparable. In total, between 2016 and 2018, 117 tons of pure seeds of the new varieties were produced and distributed to fellow farmers at different locations (Table 4). Using the seed rate of 16 kg ha^{-1}, the seed obtained from this first-generation demonstration alone is sufficient to plant on over 7300 ha of land. However, with the second and third generations of farmer-to-farmer seed dissemination, the number of farmers who benefited from the scheme and area planted with improved seed is yet to be determined. In order to achieve pure or clean seed, field inspection was done in lead farmers' fields during the growing season by responsible authorities.

Table 4. Key parameters of demonstration indicating tef varieties, area planted and seed and straw yield during 2016 to 2018

Variety	No of farmers	Area planted (ha).	Seed delivered (kg)	Straw (t ha^{-1})	Seed yield (t ha^{-1})	Total output (t)	
						Straw	Seed yield
Kora	46	15.5	256	10.25	1.94	158.88	30.07
Tesfa	40	14.8	228	9.99	2.31	147.86	34.89
Dagim	30	10.5	157	10.01	2.24	105.11	23.52
Boset	38	13.5	206	8.81	2.36	118.94	31.86
Total	154	54.3	847	-	-	530.79	117.10

Farmers' mechanism to sale seeds of improved varieties

The selected lead farmers were entered into an agreement to produce seeds of the improved varieties and to sale 4-5 kg to five fellow-farmers at affordable price. But the seed quality was a big challenge to sell to fellow farmers. As an entry point, between 2016 and 2018, farmers were trained to devise mechanisms to ensure seed quality. After the training, the lead farmers agreed to constitute a farmers' fields monitoring team (5-6 farmers) to have direct control over seed production, quality, and distribution. The researcher and the team were obliged to do regular field visits and inspections to certify the seed quality produced by the project members. Lead farmers were also trained to file and report the cultivated area allotted for seed production and the quantity of seed they sold to fellow farmers for follow-up. Through the farmers' field monitoring team, the lead farmers reported the area cultivated for seed production and the quantity of seed sold to fellow farmers (Table 5).

The highest yield was 3.2 t/ha from *Dagim* variety. This was a success story for our project. The question was whether this high amount of productivity could be maintained in large cluster fields. This depends on the scale of intensification and the level of technology applied. According to some farmers, the maximum farm size managed by an individual farmer without comprising the productivity is 1-2 ha^{-1} above which the optimum farm operations such as sowing, weeding, and harvesting could not be made at the right time.

Theoretically, as the area increases beyond the optimum, the yield per ha declines. This is the effect of area spillover. In the long run, we need to introduce farm technology to make feasible the production of tef on large-scale farmers' fields. Without addressing the critical shortage of labor at harvesting and threshing, it is difficult to produce 3.2 t ha^{-1} and more tons from large-scale farmers' fields.

Table 5. Sales category, area planted and number of lead farmers in each category during 2016 to 2018

Sales category (Birr)		Area planted	No. of farmers	%
Birr	Kg	(ha)	(n = 154)	
<9000	<300	0-0.12	76	49.35
9001-18000	301-600	0.13-0.25	30	19.48
18001-36000	601-1200	0.26-0.50	25	16.23
36001-72000	1201-2400	0.51-0.75	14	9.09
72000-96000	2400-3200	0.75-1.00	9	5.84
> 96000	> 3200	>1	0	0

Project Success Story: Case study

Tadesse Geberemariam, a 47-year-old farmer from Moretna-Jirru, 196 km north-west of Addis Ababa has been involved in improved variety seed production for the last three years. He was one of the 88 farmers who produced 3.2 t/ha^{-1} during the 2018 cropping year. He earned more than 96,000 Birr per hectare from selling pure seed of *Dagim* variety, which was distributed to farmers through the *Woreda* Agricultural Office. Prices offered were 20% more than the contemporary market prices of tef grains.

Cost structure

a) Input costs

Depending on the varieties and production seasons, the variable costs ranged from 20,859.27 to 24,831.70 Ethiopian Birr (ETB) per ha while the average variable were 23, 427.13 ETB ha^{-1}. Out of the total estimated variable costs, labor and fertilizer represented 58% and 22%, respectively. The costs that the farmers incurred vary from year to year depending on the costs for procurement of the various inputs.

b) Labor costs

In developing countries, the vast majority of the labor force is concentrated in agriculture. However, labor becomes very scarce at the time of harvesting. The situation gets worse when small rains appear during the harvesting period of tef as the demand for labor gets high thereby increasing the wages for tef harvesting. This means labor supply fails to keep pace with demand during harvesting. As a consequence, labor wages tend to rise. Due to these constraints in labor shortage and unexpected rise in harvesting costs, introducing farm machinery becomes mandatory to overcome the problem of a critical shortage of labor during harvesting. Farm machinery reduces the drudgery of farm work and facilitates the optimum period for tef harvesting and threshing. The study revealed that the lion's share of the total production costs went to labor (58%).

c) Oxen costs

In many developing countries like Ethiopia, oxen are the principal source of draft power as they are involved in several activities including plowing, planting, and threshing. Oxen traction is indispensable in diverse terrains and soil types. Of the total oxen-hours, 61% was allocated to threshing and 28% to plowing. Normally, farmers employ more daily laborers and acquire additional oxen to perform threshing in a short period of time to avoid losses due to untimely rainfalls that damage the crops.

Evaluation of the performance of tef varieties

Farmers were provided with 5 types of criteria to evaluate the performances of the varieties in seed yield, days to maturity, plant height, tolerance to shoot fly (*Atherigona hyalinipennis*), and frost escape. Regardless of the diverse agro-ecological conditions within which the demonstration trials were conducted, farmers ranked first the early maturing variety *Boset,* which displays high plasticity, and is consequently more productive than other varieties under variable weather conditions, particularly under extended or short rainfall conditions (Table 6). On the other hand, the late-maturing *Dagim* and *Kora* varieties were less preferred by farmers since they were frequently exposed to terminal drought and had little chance to escape frost when there is drought followed by frost. This indicates that, in general, farmers prefer early maturing tef varieties since these enable farmers to harvest ahead of other crops, especially during the critical period of grain filling, and they also fetch better prices than the late-maturing varieties. In most semi-arid areas like *Minjar* and *Ada'a*, *Boset* and *Tesfa* varieties were more preferred by most farmers.

Table 6. Overall farmers' ranking of tef varieties using 1 (least preferred) to 5 (most preferred) scale

Variety	Seed yield	Maturity	Plant height	Shoot fly tolerance	Frost escape	Mean	Rank
Kora	4.58	3.52	4.73	4.60	3.34	4.15	4
Tesfa	4.64	4.72	4.70	4.75	4.60	4.68	2
Dagim	4.60	3.53	4.75	4.78	3.35	4.20	3
Boset	4.68	4.98	4.40	4.73	4.90	4.74	1

Estimates of gross margin

Given the input and output prices that prevail in the selected districts, the mean revenue and mean variable costs of the farming operation were estimated to determine the mean gross margin of the demonstration trials (Table 6). Thus, the mean gross margins were 45,885.59 ETB ha^{-1} for tef variety *Tesfa*, 42,918.73 ETB ha^{-1} for variety *Boset*, 43,965.88 ETB ha^{-1} for variety *Dagim* and 35,612.91ETB ha^{-1} for variety *Kora*. The mean variable cost of production for variety *Kora* was a bit higher than that of the other varieties since it required additional labor for harvesting and threshing (the seed does not easily separate from the chaff).

Tef straw value was also considered because farmers believe that it adds to the gross margin as it is used either to feed their cattle or sold for different purposes (feed, house plastering, bedding). The straw prices were collected from the four study districts to estimate the gross revenue obtained from sales of this residue. Therefore, the total revenue is the sum of revenues obtained from both the seed and straw yields.

Finally, the benefit-cost ratio of each variety was determined to obtain the return from a unit of investment. Accordingly, *Boset* tef variety gave the highest benefit-cost ratio followed by *Tesfa* variety (Table 7).

Table 7. Average variable costs, gross benefits and net profits obtained from each improved tef variety

Costs and benefits	Improved variety *Kora* (n = 46)	*Boset* (n = 38)	Tesfa (n = 40)	Dagim (n = 30)	Mean value (n = 154)
Costs					
Seed (ETB ha^{-1})	450.00	450.00	450.00	450.00	450.00
Fertilizer (ETB ha^{-1})	4,291.30	4,291.30	4,291.30	4,291.30	4,291.30
Labor (ETB ha^{-1})	14,362.40	10,950.75	13,572.95	13,645.54	13,132.91
Oxen (ETB ha^{-1})	5,728.00	5,167.22	5,632.16	5,685.28	5,553.12
Total variable costs (ETB ha^{-1})	24,831.70	20,859.27	23,946.41	24,071.12	23,427.13
Fixed costs* (ETB ha^{-1})	3,103.96	2,607.41	2,993.30	3,008.89	2928.39
Total costs (ETB ha^{-1})	27,935.66	23,466.68	26,939.71	27,080.01	26,355.52
Benefits					
Seed yield (ETB ha^{-1})	48,375.00	53,200.00	57,850.00	56,025.00	53,862.50
Straw yield (ETB ha^{-1})	12,069.61	10,578.00	11,982.00	12,012.00	11,660.43
Total revenue** (ETB ha^{-1})	60,444.61	63,778.00	69,832.00	68,037.00	65,522.90
Gross margin (ETB ha^{-1})	35,612.91	42,918.73	45,885.59	43,965.88	42,095.78
Profit (ETB ha^{-1})	32,508.95	40,311.32	42,892.29	40,956.99	39,167.39
Benefit-cost ratio	1.16	1.72	1.59	1.51	1.50

** Fixed costs contribute for 12.5% of the total variable costs*
***Seed and straw were priced at 25.0 and 1.2 ETB kg^{-1}, respectively*

Conclusions and Recommendations

The seed yield from the four tef varieties was comparable which ranges from 1.94 t ha^{-1} from *Kora* variety to 2.36 t ha^{-1} for *Boset* variety. The main problems for low productivity in many tef growing areas are poor seedbed preparation, lodging, post-harvest losses and pests.

Given the input and output prices that prevail in districts where demonstrations were made, farmers obtained a net profit of 39,167.39 Birr ha^{-1}. This high amount of profit is due to high revenue (65,522.90 Birr ha^{-1}) and low production costs (26,355.52 Birr ha^{-1}). Due to this, host farmers substantially benefited from using improved tef seeds, although limitations in the amount and quality of improved tef seeds are expressed by farmers. Therefore, the seed production system must be further strengthened to supply sufficient quantity and adequate quality of improved seeds of the new varieties to farmers at affordable prices.

Similar studies using staple cereal crops showed that productivity is enhanced using better quality seeds. Hence, the use of improved varieties and management practices play a vital role in sustaining high yield in tef husbandry.

In general, our three-year study revealed that the seed-business-oriented demonstration trials enabled lead farmers to produce a high amount of seed which were distributed to fellow farmers at a premium price. This farmer-to-farmer seed exchange system facilitates the process, especially in terms of access to quality seed. Because farmers have access to the new varieties while they are growing in the fields of lead farmers from whom the former will purchase the seeds for the next season of cultivation.

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