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Analysis of Smallholder Farmers' Seed Utilization Trends for Major Cereal Crops During the 'Meher' Season in Ethiopia

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Abstract
Seed is a key input for improving crop production and productivity. However, in Ethiopia, like other many developing countries, farmers have not yet been able to fully benefit from the advantages of using improved seed. This review paper was aimed at to reviewing the trend of improved seeds utilization for the major cereal crops (Tef, Maize, Wheat, Barley and Sorghum) in Ethiopia. The trend for improved seed used by the smallholder farmers in the year 2004/05 and 2020/2021 'Meher' cropping season at national and regional levels was assessed. For each year cropping Meher season and each crop type, national and regional data on the total number of households (hhs); the number of hhs who used improved and/or local seed; the total area sown; and the area covered with improved and local seed were obtained from the annual report on farm management practices by the Central Statistical Agency (CSA) of Ethiopia. For each crop, the compounded annual growth rate (CAGR) of seed used was estimated by transforming the exponential trend model to semi-logarithm trend function. The results revealed that the CAGRs for the number of hhs that used improved seed for major cereal crops, and the area a particular crop covered with improved seed were positive at national level, which indicated an increasing trend in improved seed used. However, the results also revealed that the CAGRs for the number of hhs that used local seed for cereal crops and the area covered for a particular crop with local seed were also positive except maize and barley. Depending on the type of the crop, improved seed users increased at CAGR of 3.11% (sorghum) to 21.66% (Tef). Similarly, the area covered by improved seed increased at CAGR of 1.47% (sorghum) to 18.74% (Tef). The amount of improved seed used increased at CAGR of 3.17% (sorghum) to 16.58% (maize). Depending up on the type of crop, local seed users increased at CAGR of 0.08% (barley) to 2.65% (sorghum). Similarly, area covered by local seed increased at a CAGR of -1.43% (maize) to 2.84% (sorghum). The amount of local seed used increased at CAGR of 0.07% (maize) to 3.94% (sorghum). Generally, there is an increasing trend towards utilization of improved seeds as compared to local seed for all major crops, except sorghum.
Keywords: Cereal crops, Compounded annual growth rates, improved seed, Local seed, Seed use trend, Smallholder farmers.
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Introduction

Seed is a key input for improving crop production and productivity. Increasing the quality of seeds can increase the yield potential of the crop by significant folds and thus, it is one of the most economical and efficient inputs to agricultural development (FAO, 2006). Generation and transfer of improved technologies are critical prerequisites for agricultural development particularly for an agrarian based economy such as of Ethiopian. Despite the release of several technologies, particularly of improved crop varieties, there has been limited use of improved seeds by the majority of farmers (CSA, 2010).

Most crops started from seed, nothing substitutes the essence of seed for crop production. Entirely, it has a great impact for the development of Ethiopia since agriculture sector plays a leading role in the country's economy. Hence, the seed quality should be engaged with proper system to increase quality and quantities of crop production. An increasing of seed quality can increase the yield potential of the crop by significant folds. Hence, seed security could be considered as a part and parcel of food security. Production of seed requires a wide structure with appropriate skill, knowledge and specialization which exercised by a seed system in one way or another. One of the first things to be recognized by the seed system is covering a series of quite distinct operations and responsibilities. These include plant breeding, source of seed production, seed multiplication, quality control, conditioning, storage and marketing. So, the seed system should be taken or played a lion share for seeds required to improve crop production.

Production and productivities of crops or agriculture at large in Ethiopia is constrained by the seed system due to the non-availability of seed in quality and quantity. The demand for improved seed is still increasing rapidly from time to time, but its supply has not yet fulfills the farmers' requirements. Among others, unavailability of quality seeds at the right place and time coupled with poor promotion system is one of the key factors accounting for limited use of improved seeds which further contributing for low agricultural productivity. Poor availability and promotion of improved seeds was due to inefficiency of seed systems of the country. Farmers' access to seed

is increasingly theorized in terms of two closely related concepts: seed systems and seed security (Sperling and McGuire (2012), Niels and Walter (2012)). The seed system concept has deep roots and various fields from crop science to agricultural anthropology and economics have contributed to the current understanding of seed systems as the activities, institutions, and actors involved in the development, distribution, and use of seeds (Brush, 2004). Seed security is a more recent concept. The Food and Agriculture Organization of the United Nations (FAO) defines as ready access by rural households (hhs), particularly farmers and farming communities, to adequate quantities of quality seeds and planting materials of crop varieties, adapted to their agro ecological conditions and socioeconomic needs, at planting time, under normal and abnormal weather conditions (FAO, 1997).

For decades, the Ethiopian government followed a linear model of formal seed sector development policy focusing on the development of improved high-yielding varieties and the distribution of certified seeds to farmers to increase national food security (McGuire, 2005; Bishaw *et al*., 2008; Louwaars *et al.*, 2013; Fikre *et al.*, 2012; Mucioki *et al*., 2018).

The previous policy in Ethiopia aimed to replace the informal seed system with the formal seed system. However, this policy has now shifted to support the diverse seed systems that farmers use, including both market and non-market channels to increase seed security. The policy recognizes the existence of three seed systems: informal, formal, and intermediate, which perform differently in terms of seed security for various crops (MoA, 2019; MoA and ATA, 2017). The informal seed system involves farmers' selection, multiplication, storage, use, and distribution of seeds through social seed networks and local markets. It is the dominant system in terms of delivering large quantities of diverse crop varieties (Fikre et al. (2012), Coomes, et al. (2015) McGuire and Sperling (2016), Pautasso et al. (2013), including traditional and improved varieties that have been integrated into the local seed system, called "obsolete" improved varieties (Bishaw et al., 2010). The formal seed system involves public and private sector institutions and a linear series of activities along the seed value chain, including germplasm conservation, plant variety development, variety release and registration, quality seed production, and distribution (Louwaars et al., 2013).

Seed use trend

In general, major seed system constraints in Ethiopia are inadequate seed marketing information and infrastructure, disease and pests introduction due to quarantine problem, lack of a clear seed strategy, inefficient extension services, limited collaboration within the seed sector, private companies tending to concentrate on profitable crops, lack of awareness and knowledge gap about seed production, inadequate basic seed supply, budget limitation for field inspection,and lack of effective large scale seed enterprise and industry (Fasikaw, 2019).

A sustainable seed system will ensure that high quality seeds of a wide range of varieties and crops are produced and fully available in time and affordable to farmers and other stakeholders. However, in Ethiopia, like in many developing countries, farmers have not yet been able to fully benefit from the advantages of using improved seed. So, the objective of this paper is: The aim of this review article is to examine the trends of using improved seeds and identify the issues and prospects associated with seed utilization, which can potentially enhance the food security status of the country. The article also intends to offer significant insights for policymakers and other stakeholders working to improve agricultural practices in Ethiopia.

Methodology

Description of Regional States and Crop Growing Seasons

Ethiopia has 11 regional states and two city administrations, Addis Ababa and Dire Dawa. Oromia, Amhara, Southern Nation, Nationality and Peoples (SNNP) and Tigray are the major (ca. 95 to 99%) grain, vegetable and fruit producer regions; while the Afar, Somali and Gambela regions are dominated by nomadic livestock producers. In the Benshangul-Gumuz (BeGu) region, some crop species (maize, sorghum, ground nut, soybean, sesame and mango) are produced along with livestock. The Harari region produces chat *(Catha edulis)*, sorghum, vegetables and few fruit crops (Tebkew, 2019). The Sidama and the Southwest regions are recent divisions from the SNNP region and separate data are not available for them. The seed use data at regional level were taken from Oromia, Amhara, SNNP and Tigray regions.

In Ethiopia, the timing of cropping season is divided into “Meher” season (sowing time June to August and harvesting time September to February) and “Belg” season (sowing time January to March and harvesting time March to August). For this study, only the Meher season seed use by smallholder farmers was considered. Besides, the analysis focuses solely on seed use in major cereal crops such as Tef, wheat, barley, sorghum.

Data Collection Approach and Analysis

For each cropping season from 2004 to 2020 inclusive, and for each crop type national and regional data on the total number of hhs, the number of hhs who use improved seed, the number of hhs who use local seed, the total area sown, and the area covered with improved and local seed were obtained from the annual report on farm management practices by the Central Statistical Agency of Ethiopia (CSA 2005 to 2021). Each datum set was

graphed to generate a time plot to visualize the datum and investigate if there is any pattern exists overtime. Moreover, the Durbin-Watson Statistic was used as criterion to detect serial autocorrelation. These preliminary analyses revealed the presence of a first and second order serial autocorrelation (regardless of the significance level) and a non-linear relationship between time and all the variables mentioned above.

Consequently, the compounded annual growth rate (CAGR) of improved seed use were estimated by transforming the exponential trend model ($Y_i = {}_0{}^{x_i}$) to semi-logarithm trend function, which is Log10Yi = b0 + b1Xi ; where Yi = number of households, hhs who used improved seed on a particular crop, hhs who used local seed on a particular crop, area under a particular crop or area covered with improved and local seed in year Xi; b_0 is the mean number of households, hhs who used improved seed on a particular crop, hhs who used local seed on a particular crop, area under a particular crop or area covered with improved and local seed in 2004 crop season; b1 the parameter that measures the CAGR per annum. A trend is detected when the b1 is significantly different from zero (Gerrodette, 1987). Since the exponential trend model was used, b1 was converted to CAGR (%). As indicated before, because of the presence of variable level of first and second order serial autocorrelation, each datum set was analyzed using MS Excel. Furthermore, the percentage of area coverage or the percentage of hhs who used the improved seed in any one year was calculated with the following two formulas:

$$\text{Proportion (\%) of households who sow improved seed} = \frac{\text{Households who sow improved seed of the specific crop}}{\text{Total households who grow the specific crop}} X100 \text{--------- [1]}$$

$$\text{Proportion (\%) of area covered by improved seed} = \frac{\text{Area coverd by improved seed of the specific crop}}{\text{Total area covered by the specific crop}} X100 \text{------- [2]}$$

Results and Discussions

Between 2004 and 2020, the five major cereal crops produced were tef (*Eragrostis tef*), barley (food and malt types), wheat (bread and durum wheat), maize and sorghum; while the minor cereal crops cultivated were finger millet (*Eleusine coracana*), *Aja* (*Triticum dicoccum*), Ethiopian oat (*Avena abyssinica*), triticale (*Triticosecale* Wittmack), rice (*Oryza sativa*), and pear millet (*Pennisetum glaucum*). Except for barley in which distinct trends were not detected in the total number of barely grower hhs and the total area under barley, the total number of hhs who grew and the total area under each major cereal crop had significantly increased at both national and regional levels (Tables 1 and 2).

Table 1. Area (ha) sown to major cereal crops in 2004/05 and 2019/20 cropping seasons in main crop producer regions of Ethiopia

Region/ Nation	Crops and seasons									
	Tef		Barley		Wheat		Maize		Sorghum	
	2004	2020	2004	2020	2004	2020	2004	2020	2004	2020
Tigray	137,360	188,392	95,453	85,432	87,785	102,258	47,200	80,152	142,038	232,636
Amhara	852,307	1,086,375	375,912	311,401	392,722	641,170	285,242	595,086	411,949	597,441
Oromia	918,461	1,393,456	532,141	440,702	765,528	996,364	791,686	1,371,868	522,499	676,075
SNNP	210,055	234,351	84,936	75,440	131,485	147,641	207,410	313,799	92,009	62,926
Ethiopia	2,135,553	2,928,206	1,095,436	926,107	1,398,215	1,897,405	1,392,916	2,526,212	1,253,620	1,679,277

Source: compiled from CSA 2005 and 2021

The studies try to summarize the number of households growing major cereal crops in all regions of Ethiopia over the past two decades. For instance, the number of households growing Tef increased from 4,857,682 in 2004 to 6,866,855 in 2020 at the national level. In Tigray, the number of households growing Wheat increased from 370,776 in 2004 to 419,786 in 2020, while in Oromia, the number of households growing Maize increased from 1,722,661 in 2004 to 1,832,546 in 2020.The highest number of households growing major cereal crops was recorded in Amhara region, with the number of households growing Wheat ranging from 1,252,127 in 2004 to 1,906,639 in 2020. On the other hand, the lowest number of households was recorded in Tigray region, with the number of households growing Sorghum ranging from 270,380 in 2004 to 558,917 in 2020.

Overall, the data suggests that the number of households growing major cereal crops in Ethiopia has significantly increased over the past two decades. This increase can be attributed to various factors such as the expansion of agricultural extension services, improved access to credit, and the implementation of policies that promote smallholder agriculture. However, the variations in growth rates across different regions and crops highlight the need for targeted interventions to address the specific needs and challenges faced by smallholder farmers in different regions.

Table 2. Number of households who grew major cereal crops in 2004/05 and 2019/20 crop seasons in the main crop producer regions of Ethiopia

Region/ Nation	Crops and seasons									
	Tef		Barley		Wheat		Maize*		Sorghum*	
	2004	2020	004	2020	2004	2020	2004	2020	2004	2020
Tigray	395,681	633,525	370,776	419,786	287,946	386,778	394,632	835,782	270,380	558,917
Amhara	1,839,987	2703282	1,475,667	1290159	1,252,127	1906639	1,780,595	2,978,454	895,059	1191608
Oromia	1,822,436	2861364	1,427,362	1509055	1,722,661	1832546	3,089,557	5205203	1,782,165	2321488
SNNP	767,677	1224860	597,800	789117	626,620	761835	1,199,744	1372318	549,905	562834
Ethiopia	4,857,682	6866855	3,902,139	3738220	3,937,682	4579491	6,677,356	10189355	3,674,865	4323086

* Note: considerable number of households in Benshangul-Gumuz that produce maize and sorghum, Source compiled from CSA 2005 and 2021

The CAGRs for the number of hhs who grow each of the major cereal crops and the area for each particular crop were positive except the area of Barley, which indicate an increasing trend in area of production and producers of major cereal crops (Table 3). The number of hhs who used improved seed of each major cereal crop and the area covered by improved seed of each particular crop was positive, which indicate an increasing trend in the utilization of improved seed. However, the number of hhs who used local seed for each major cereal crop and the area covered by local seed of each crop was positive except the area of barley and maize, which indicate an increasing trend in utilization of local seed as well. The amount of improved and local seed used of each major particular crop was positive, which indicate an increasing trend in utilization of improved and local seed. However, the trend of improved seed utilization has a higher proportion as compared to local seed except sorghum.

Table 3. Compounded annual growth rate (%) of households who used improved and local seed and total area and area covered with improved and local seed of major cereal crops between 2004 and 2020 cropping seasons in Ethiopia

Descriptions	Tef	Wheat	Barley	Maize	Sorghum
Total area coverage	2.9	1.71	-1.12	3.75	2.78
Total holders	2.8	1.42	0.1	3.66	2.51
Total area covered by local seed	2.68	1.11	-1.2	-1.43	2.84
Total area covered by improved sees	18.74	11.42	13.2	16.22	1.47
Holders used local seed	2.63	0.78	0.08	1.53	2.65
Holders used improved seed	21.66	13.01	12.69	15.44	3.11
Amount of local seed used (Qt)	2.71	3.69	0.38	0.07	3.94
Amount of improved seed used (Qt)	16.58	11.76	17.72	18.26	3.17

Source: Authors computation from CSA data 2004-2021

The proportion of hhs who sow improved seed was computed by formula: 1 as indicated in the methodology part. Maize found that it have highest proportion improved seed used holders (47.96%) as compared to other cereal crops whereas wheat is the second crop (20.98%)by proportion of hhs used improved seed. The minimum proportion was recorded for sorghum followed by Barley. The area proportion of maize was to be found the highest followed by wheat and Tef, respectively (Table 4 and 5). This is because of weak seed system of sorghum like the crop nature and low demand of sorghum producers for improved seed. The open pollinated variety (OPV) type does not encourage seed enterprises to multiply every year because of limited demand and seed quality deterioration. Normally, the demand for improved sorghum seed by farmers was not well-built enough. Accordingly, unlike wheat and maize commodities, sorghum seed production by Ethiopian Seed Enterprise (ESE), Regional Seed Enterprise (RSE), private seed companies was very limited. Moreover, there are no well-organized informal sorghum seed producers that able to supply improved sorghum seed with the required quality and quantity. The absence of strong and efficient formal and informal improved sorghum seed producers became a huge challenge for the sector (MoA and ATA, 2015). The demand for improved sorghum seeds by sorghum producers is very discouraging. In addition to high seed yield and superior *injera* making quality traits, farmers preferred sorghum varieties that have high biomass yield, a trait preferred by farmers for animal feed, fire-wood and construction. However, most of the released sorghum varieties are early maturing, that are generally characterized by low biomass yield. In spite of the consistent advice of extension workers and the availability of improved sorghum seeds, most of the farmers are reluctant to adopt improved early maturing sorghum varieties and tend to grow long maturing sorghum landraces (MoA and ATA, 2015).

Table 4. Proportion (%) of households who sow improved seed of major cereal crops in 2004 and 2020 crop seasons

Year	Tef	Wheat	Barley	Maize	Sorghum
2004	0.96	4.53	0.80	11.61	0.93
2005	1.38	6.56	0.87	15.40	0.50
2006	0.57	3.77	0.32	10.60	0.27
2008	0.73	4.59	0.71	13.03	0.19
2009	2.35	4.13	1.18	15.74	1.78
2011	2.45	9.86	0.85	21.70	0.23
2012	2.09	5.57	0.64	23.41	0.11
2013	4.62	7.70	0.81	27.56	0.37
2014	3.49	9.22	0.81	31.97	0.28
2016	4.31	15.43	1.40	34.00	0.40
2017	2.62	7.93	1.86	35.08	0.53
2018	9.86	25.18	5.64	43.20	1.50
2019	7.03	17.16	4.60	40.49	1.24
2020	8.40	20.98	5.67	47.96	2.07

Source: compiled from CSA 2005 and 2021

The proportion (%) of area covered by improved seed of major cereal crops in Ethiopia during the years 2004 and 2020 crop seasons calculated with formula 2 indicated in methodology part. The result reveals that the proportion of area covered by improved seed has increased significantly for all major cereal crops over the years. For example, in 2004, only 0.72% of the area cultivated with Tef was covered by improved seed, but by 2020, this proportion had increased to 6.49%. Similarly, the proportion of area covered by improved seed for wheat increased from 3.82% in 2004 to 18.64% in 2020. However, there are variations in the growth rates across different crops. For instance, the proportion of area covered by improved seed for sorghum has remained relatively low compared to other crops, with only 0.50% in 2004 and 1.49% in 2020.

Table 5 shows the proportion (%) of area covered by improved seed of major cereal crops in Ethiopia in 2004 and 2020 crop seasons. The data reveals a significant increase in the proportion of area covered by improved seed of all major cereal crops over the past two decades. In 2004, Tef had the highest proportion of area covered by improved seed at 0.72%, while Maize had the highest proportion of area covered by improved seed in 2020 at 59.49%.

Table 5. Proportion (%) of area covered by improved seed of major cereal crops in 2004 and 2020 crop seasons

Year	Tef	Wheat	Barley	Maize	Sorghum
2004	0.72	3.82	0.52	15.91	0.50
2005	1.10	5.73	0.78	20.17	0.38
2006	0.55	3.25	0.32	15.87	0.17
2008	0.67	3.85	0.62	19.75	0.09
2009	1.73	2.25	0.77	11.84	1.01
2011	1.83	8.39	0.97	30.64	0.21
2012	1.41	4.35	0.86	33.47	0.04
2013	3.13	5.62	0.63	40.01	0.18
2014	2.52	7.35	0.60	46.38	0.11
2016	2.92	9.73	1.53	51.04	0.28
2017	1.85	6.56	1.94	54.95	0.31
2018	2.86	11.11	2.97	58.18	0.11
2019	6.61	17.30	4.86	57.49	0.92
2020	6.49	18.64	6.05	59.49	1.49

Source: compiled from CSA 2005 and 2021

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