# Cost-Benefit Analysis of Early Generation Seed Production: The Case of Public Seed Enterprises and Research Institutes in Ethiopia

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## Abstract

*Understanding the cost of production of early generation seed (EGS) at public seed enterprises and research institutes in Ethiopia can help to better understand the need for greater specialization in terms of the crop type and the seed class. This study was conducted to assess the production costs of pre-basic and basic seed for tef (Eragrostis tef), wheat (Triticum aestivum), barley (Hordeum vulgare), maize (Zea mays L.), and faba bean (Vicia faba), and formulate recommendations to improve early generation seed (EGS) supply and contribute to the seed sector development in the country. The study was conducted in Amhara, Oromia, and South Ethiopia and Sidama regional states and included EGS producers from federal and regional research institutes and public seed enterprises. A structured questionnaire was used to collect primary data directly from producers on EGS production costs and sale prices from producers. Besides, key informant interviews were conducted with technical experts and managers from research centers, seed enterprises, private companies, and seed unions. Descriptive and budgetary techniques such as profitability analysis, break-even analysis and sensitivity analysis were employed for data analysis. The results showed that the EGS production of tef, wheat, and maize was profitable to research institutes and public seed enterprises. Barley EGS production for research institutes and faba bean EGS production for both research institutes and public seed enterprises were not profitable. Possible causes of low profitability are discussed and interventions for a sustainable EGS business production recommended.*

**Keywords:** Break-even; Early generation seed; Profitability; Seed enterprises; Sensitivity

## Introduction

In Ethiopia, the organized seed sector has now registered over 40 years of its existence. From a national context, three seed systems have been recognized: formal, intermediate, and informal systems (ATA, 2016). Currently, several large-scale public seed enterprises, small to medium private seed companies, numerous grassroots level seed producer cooperatives, community-based seed producers with supports of development projects are operating in the country working on quality seed supply of cereals, legumes, forage crops (Atilaw et al., 2017; Bishaw and Atilaw, 2016; Kalsa, 2019; Kalsa et al., 2021; Kifle et al., 2022). Moreover, quality declared seed scheme was introduced to expand the business choice of seed

producers and quality choice for farmer seed users (Hassena et al., 2023).
The formal seed sector is highly dominated by the public sector from technology generation to seed production and marketing. These include federal and regional agricultural research institutes and federal and regional public seed enterprises. The private seed companies mainly engage in a few crops, particularly the hybrid maize seed business (Bishaw and Louwaars, 2013).

In Ethiopia the responsibility of early generation seed (EGS) (breeder, pre-basic and basic) production of public-bred varieties is diffused and divided between public National Agricultural System (NARS) and seed enterprises (Atilaw et al., 2017; Kalsa et al., 2021). In the early years of seed sector development Institute of Agricultural Research (IAR) and the Ethiopian Seed Enterprise (ESE), respectively were the only public breeding program and seed production enterprise in the country. To resolve the shortage of EGS production, IAR was assigned a responsibility for variety maintenance and breeder seed production whereas the ESE was given the mandate to produce pre-basic and basic seed at its two basic seed farms established at Gonde-Eteaya and Awassa-Shallo, respectively to address the highland and lowland crops.

However, following seed sector reforms in the early 1990s and later with decentralization of agricultural research system, establishment of public seed enterprises and entrance of private seed sector, the roles and responsibilities of these new entities become less apparent. In the meantime, demand for EGS soared whereas production lagged leading to mismatch between supply and demand. In Ethiopia, the federal and regional agricultural research institutes are the major sources of improved crop varieties with little contribution from the private sector, mainly of foreign sources. Commercialization of public-bred varieties remain a big challenge due to lack of clear policy guidance, overlapping institutional responsibilities and lack of binding contractual agreement in EGS production and supply (Atilaw et al., 2017; Kalsa et al., 2021). There is an overlapping arrangement for EGS production between NARS and seed producers, the example being the involvement of National Agricultural Research System (NARS) and Public Seed Enterprises (PSEs) in both pre-basic and basic seed productions.

A recent analysis of the mandates of federal and regional agricultural research institutes and federal and regional PSEs in EGS production (Kalsa et al., 2021) clearly showed that except for South Ethiopia Agricultural Research Institute (SEARI) and South Seed Enterprise (SSE), there is lack of clarity on the roles and responsibilities between the research and seed enterprises. Given the critical role and importance of EGS, in scaling agricultural innovations leading to varietal adoption and impacts, and growing demand and critical shortage of EGS, interest in EGS production and supply attracted the attention from government and development partners alike. For example, a study on EGS was conducted where four archetypes of EGS production have been proposed based on commercial attractiveness and potential certified seed demand of the crop in Ethiopia (ATA, 2016). The study also prioritized crops and categorized crops to archetypes models and recommended interventions. Similarly, a continental wide study was conducted across Africa on EGS, and a meeting was convened where different models for commercial and sustainable EGS was suggested for different crops such as public-sector or research-led models, private-sector models, and public-private partnership models (Lion et al., 2015).

Atilaw et al. (2017) and Kalsa et al. (2021) highlighted the major challenges of EGS production in Ethiopia and recommended the need for the establishment of seed units within the public breeding programs at federal and regional levels which is equipped with basic physical facilities and sufficient human and financial resources. It was suggested that the future strategy for EGS production could be a sustainable commercial operation, which gradually may lead to greater profitability.

To date, EGS production faces myriad of constraints that it is public sector dominated and funded by the government; least commercial oriented and lack incentives (FAO, 2015); lack proper recording and effective monitoring system of production costs (Hassena et al., 2022). Moreover, complexity of analyzing EGS production costs as it involves set of different activities (Cramer, 2019); involvement of many in EGS production; different pricing modalities which is not based on the actual production costs; and the need for capital investments (Kalsa et al., 2021) exacerbate the problem and contribute to the difficulty of setting the seed price and measure the profitability and sustainability of EGS production.

Therefore, this study was designed to systematically analyze the actual production cost of EGS by different producers, including public research institutes, public seed enterprises, private companies, and seed unions. Moreover, it aimed to formulate recommendations for increased market-orientation of EGS production, i.e., price setting considering the actual production costs. The study also aimed at identification of the appropriate seed class and crop for EGS production by research institutes and public seed enterprises.

# Materials and Methods

## Study Area

The study was conducted in Amhara, Oromia, Sidama, and South Ethiopia regions. Cross sections of EGS seed producers were included from federal and regional research institutes, federal and regional public seed enterprises (Table 1).

### Sampling techniques

A purposive sampling was employed to identify EGS producers. The producers were selected based on defined criteria: (i) active contribution to EGS production and supply to the formal market both in terms of quantity and quality, (ii) long years of experience in EGS production and marketing, and (iii) seed production experience of diversified crops and varieties. Therefore, the sample include federal (EIAR) and regional agricultural research institutes (RARIs), as they are more active in production of breeder and pre-basic seed (ARARI, OARI and SARI); federal (EABC) and regional public seed enterprises (OSE and ASE), as well as private companies and seed unions which are more active in pre-basic and basic seed production. Table 1 presents the list of EGS producers included in this study. EGS production cost varies with the type of crops and the seed classes depending on the seed multiplication factors and management.

Table 1: List of early generation seed producers in the study

| Type of institutions | Federal[1] | Amhara[2] | Oromia[3] | South[4] |
|---|---|---|---|---|
| Research Institutes | Debre Zeit ARC | Adet ARC | Sinana ARC | Areka ARC |
| | Kulumsa ARC | Debre Berhan ARC | Bako ARC | Hawassa ARC |
| | Holeta ARC | | | |
| | Bako NMRC | | | |
| Public seed enterprises | EABC | ASE | OSE | |

Note:
[1]EIAR-Ethiopian Institute of Agricultural Research; [2]ARARI- Amhara Regional Agricultural Research Institute; [3]OARI- Oromia Agricultural Research Institute; [4]SARI- South Agricultural Research Institute; ARC- Agricultural Research Center; NMRC- National Maize Research Center
EABC- Ethiopian Agricultural Business Corporation; OSE- Oromia Seed Enterprise; ASE- Amhara Seed Enterprise.

Five major cereal and legume crops were selected for the study i.e, tef, wheat, barley, maize, and faba bean. These crops were selected for two reasons: (i) They contribute to the largest share of EGS production in the country, and (ii) most of the producers are engaged in the production of either of the crops or all of the crops. The average pre-basic and basic seed production by the EIAR on those five crops during the last three years was about 554.3ton. Public seed enterprises produced about 496.2ton of pre-basic seed and 10,496.8ton basic seed during the year 2022 (Unpublished data). About 93% of the pre-basic seed and 94% of the basic seed produced by public seed enterprises were wheat, maize, barley and tef. EGS production cost analysis for breeder seed was not included due to lack of cost information from producers.

### Research design and approach

A cross-sectional research design (for quantitative data) and a narrative research design (for qualitative) were used to collect data and ensure that the data obtained would help answer the research objectives. A mixed-methods research approach was employed for an investigation involving the collection of both quantitative and qualitative data. The survey tool was pre-tested before the actual interview.

## Data collection and data sources

Both primary and secondary data sources were used for the study. Primary data on the cost of EGS production was collected directly from producers. These costs include material costs (seed, fertilizers, agro-chemicals, packaging), operational costs (labor, fuel, lubricants, and maintenance costs, etc.), rental costs (land, machinery, seed cleaner machine, storage, oxen), and other costs (seed certification fee, administration, transport, training, field day). A structured questionnaire was used to collect relevant production costs and sale prices from producers. The survey tool was pre-tested before the actual interview and administered by survey enumerators. Questions included all the production practices that are associated with costs in the context of each producer. Moreover, specific questions were included to gather specific information based on the crop type. For example, the cost of detasseling is included in hybrid maize seed production.

In addition, key informant interviews were conducted with technical experts and managers from research centers, seed enterprises, private companies, and seed unions. The aim of the interview was to assess the internal seed quality control procedures and the challenges in the seed quality control processes. Secondary data were also obtained from sources such as companies' annual reports, research reports, and monitoring reports.

## Data analysis

Descriptive and budgetary techniques such as profitability analysis (gross income or revenue, gross margin, profit margin, and benefit-cost ratio), break-even analysis (break-even price and break-even yield), and sensitivity analysis (GM, PM as % of GM/TR, and % change in GM) were employed for data analysis.

The total revenue (TR) is estimated as the prevailing market price of a given output ($P_y$) multiplied by the quantity of output sold ($Q_{ys}$). Total variable costs (TVC) are a summation of all input variable costs incurred by a given producer, and the input variable cost is estimated as the prevailing market price of a given input ($P_{xi}$) multiplied by the quantity of the input used ($Q_{xi}$).

Thus,
$TR = (\mathrm{Py} * \mathrm{Qys})$.

$TVC = \Sigma(\mathrm{Pxi} * \mathrm{Qxi})$.

$$GM = \Sigma(\mathrm{Py} * \mathrm{Qys}) - \Sigma(\mathrm{Pxi} * \mathrm{Qxi}) \ldots\ldots\ldots\ldots..(1)$$

Where GM is the gross margin,

TVC is the total variable cost,
$P_{xi}$ is the price of input i,
$Q_{xi}$ is the quantity of input i,
$P_y$ is the price of output I, and
$Q_{ys}$ is the quantity of output sold.

The profit margin (PM) was calculated by dividing net revenue by total revenue and expressed in terms of percentage, while the benefit-to-cost ratio was computed by dividing total cost (TC) by total revenue (TR) as shown below:

$$PM = \frac{NR(GM) * 100}{TR}$$

$$NFI = GM - FC$$

$$Benefit - Cost\ Ratio = \frac{TR}{TC} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where GM is the gross margin of EGS,
NFI is the net farm income of EGS and
FC is the fixed cost of the EGS production.

### Breakeven analysis

Break-even analysis was employed to determine the break-even yield and the break-even price at which the total receipts are equal to the total costs. A break-even analysis is a financial tool used to determine when a company, or a new service or product, will be profitable. In other words, it's a financial calculation for determining the number of products or services a company should sell to cover its costs (particularly fixed costs). Break-even analysis is useful in studying the relationship between variable cost, fixed cost, and revenue. Generally, a company with low fixed costs will have a low break-even point of sale. This analysis determines the break-even price and the break-even yield at which the company remains in the production process by covering the total costs incurred. The break-even price was calculated as the ratio of the total cost to total production (yield) while the break-even yield was taken as the ratio of the total cost to the sale price.

The break-even point was analyzed with the following formula:

$$Breakeven\ price = \frac{Total\ costs}{Total\ production\ (yield)} \ldots\ldots\ldots\ldots (3)$$

$$Breakeven\ yield = \frac{Total\ costs}{Sales\ price} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

### Sensitivity analysis

A sensitivity analysis was undertaken to incorporate uncertainty into an economic evaluation of EGS production. The analysis used the estimated economic values (costs and benefits). To assess the stability and profitability, the total variable cost, the seed price, and the quantity produced of EGS were subjected to a 20% reduction and an increase by the same percentage, and new gross margins were computed. The 20% variability was chosen for several reasons. First, manual operational cost (labor cost) is the highest input cost, and a rise in labor wages is assumed. Second, chemical inputs are the other most expensive inputs, as the crops are highly sensitive to different diseases and insects. Third, the selected crops are commercial crops, and their production and marketing channels cross borders.

Profitability analysis is part of enterprise resource planning. It helps producers identify ways to optimize profitability related to various projects, plans, or products. It is the process of systematically analyzing profits derived from the various revenue streams of the business. It highlights what portions of the company's sales have turned into profits. The profit margin allows producers to determine the financial health and well-being of certain companies. The gross margin of an enterprise is the amount of money a company retains after incurring the direct costs associated with producing the goods it sells and the services it provides. The higher the gross margin, the more capital a company retains. The benefit-cost ratio (BCR) is an important criterion to show the return on investment. If a project has a BCR > 1, it is expected to deliver a positive net present value (NPV) to a firm; if it has a BCR < 1, the project costs outweigh the benefits, and it should not be considered.

The collected data were analyzed using SPSS V-22 software for sensitivity analysis.

## Results and Discussion

### Results

The following results are based on the outputs of analyses of cost of production, profitability, break-even, and sensitivity in the early generation seed production process of tef, wheat, barley, faba bean, and maize by public research institutes and public seed enterprises. For the cost of production, we analyzed the material costs, operational costs, total variable costs, and total fixed costs. In the profitability analysis, we considered total revenue and total variable costs. For break-even analysis, we considered the seed yield and seed price.

### Cost-benefit and break-even analysis of pre-basic seed production

Table 2 shows the cost of production and profitability analysis for tef, wheat, barley, maize, and faba bean pre-basic seed production compared between public research institutions and public seed enterprises. The total cost of production of tef pre-basic seed by the public seed enterprises was three times higher than that of public research institutions. The operational cost for tef pre-basic seed production was nearly four times higher at public seed enterprises than at research institutions. This could be attributed to the high fuel consumption and machinery maintenance costs observed at public seed enterprises. Contrary to this at research institutions there is limited mechanization which had an implication on the operational costs. Most of the research centers operate labor intensive early generation seed production. The profit margin for research institutions in terms of tef pre-basic seed production was more than 72% while that of public seed enterprises was about 27% with a benefit-to-cost ratio of 2.96 and 1.22, respectively.

The total cost of production for pre-basic seed of wheat was considerably lower for public seed enterprises than for research institutions (Table 2). The total variable cost for wheat pre-basic seed production by research institutes was more than twice that of public seed enterprises. Hence, wheat pre-basic seed production was more profitable for public seed enterprises than for research institutions. The average profit margin for wheat pre-basic seed production by research institutes was about 65% while that of public seed enterprises was about 83% with a benefit-to-cost ratio of 2.2 and 3.9, respectively. Research institutes invested more on chemical and labor while the cost of those two items at public seed enterprises was very low. As it is indicated previously, the early generation seed production at several public research centers is labor intensive. There was no loss observed in terms of wheat pre-basic seed production both in research institutes and public seed enterprises. However, public research centers should wisely invest on chemicals and appropriate mechanization in terms of reducing the cost of wheat pre-basic seed production.

This study showed that research institutes have a negative return on investment in barley pre-basic seed production (Table 2). While there was not much difference between other items, the unit cost (cost per ton of seed) was four times higher in research institutes than in public seed enterprises. Hence, the profit margin for public seed enterprises was about 73% while that of research institutes was about 10% only. The benefit-to-cost ratio for barley pre-basic seed production by research institutes was below 1, indicating a loss.

Maize pre-basic seed production was four times more costly for research institutes than the public seed enterprises (Table 2). While the revenue per unit area of maize pre-basic seed in research institutes was more than twice that of the public seed enterprises, there was still a loss due to high variable and fixed costs. The fixed cost for pre-basic seed production by research institutes was more than 8000% of that of the public seed enterprises. As pre-basic seed production is a major enjoyment of research institutes, the fixed cost in terms of salary and overhead costs are leveraged mostly to the pre-basic seed product. This has inflated the total fixed cost of the wheat pre-basic seed production by research institutes. Such inflation in cost of production can be minimized by increasing the economy of scale.

Pre-basic seed production for faba bean by both public seed enterprises and research institutes was not a profitable business (Table 2). While there was a slightly higher cost of production in research institutes, the two entities also had a negative net return and gross margin. The benefit-to-cost ratios were 0.47 for research institutes and 0.51 for public seed enterprises.

The break-even price analysis of pre-basic seed production showed that the unit price of seed produced by research institutes was higher except for tef, compared to that of public seed enterprises (Table 2). However, the break-even price of tef, wheat, and barley was lower than the actual price at research institutes while that of maize and faba bean was higher. The break-even price of all crops except faba bean was lower than the actual price of pre-basic seed produced by public seed enterprises. Likewise, except for tef, the break-even yield for public seed enterprises was always lower. At research institutes, the break-even yield of tef, wheat, and barley was lower than the actual yield while that of maize and faba bean was higher. The analysis showed that there is a substantial gap between the break-even yield and the actual yield of faba bean for both research institutes and public seed enterprises.

Table 2. Cost-benefit and break-even analysis of pre-basic seed production of tef, wheat, barley, maize, and faba bean by public seed producers in Ethiopia

| Item description | Tef | | Wheat | | Barley | | Maize | | Faba bean | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise |
| Seed yield (Kg/Ha.) (Y) | 898.50 | 1,500.00 | 2,082.40 | 2,320.90 | 645.10 | 2,240.00 | 1,921.50 | 761.50 | 529.30 | 500.00 |
| Sales Price (Birr/Kg) (P) | 78.90 | 70.40 | 53.90 | 76.20 | 64.70 | 82.90 | 83.40 | 60.00 | 44.80 | 47.80 |
| Material cost (Birr/Ha.) (MC) | 8,241.10 | 3,498.80 | 23,991.50 | 10,947.60 | 7,954.90 | 10,869.10 | 19,572.70 | 11,303.60 | 15,946.40 | 14,520.50 |
| Operational cost (Birr/Ha.) (OC) | 18,172.60 | 77,295.50 | 10,910.60 | 5,135.30 | 21,996.10 | 16,570.30 | 55,759.70 | 30,857.60 | 39,601.40 | 25,870.60 |
| Total Variable Costs (Birr/Ha.) (TVC) | 26,413.70 | 80,794.30 | 34,902.10 | 16,082.90 | 29,950.90 | 27,439.40 | 75,332.40 | 42,161.30 | 55,547.80 | 40,391.10 |
| Total Fixed Costs (Birr/Ha.) (F) | 5,744.50 | 9,938.00 | 9,976.20 | 7,895.30 | 8,839.10 | 5,991.50 | 92,281.70 | 1,135.40 | 7,731.70 | 9,938.40 |
| Total Costs (Birr/Ha.) (TC) | 32,158.20 | 90,732.30 | 44,878.30 | 23,978.20 | 38,790.00 | 33,430.90 | 167,614.10 | 43,296.70 | 63,279.50 | 50,329.40 |
| Unit Cost (Birr/ ton) (UC) | 8.56 | 6.05 | 2.16 | 1.03 | 6.01 | 1.49 | 8.72 | 5.69 | 11.96 | 10.07 |
| Total Revenue (Birr/Ha.) (TR) | 95,090.10 | 111,000.00 | 98,835.20 | 93,029.30 | 33,227.60 | 101,138.70 | 161,183.10 | 62,533.80 | 29,546.90 | 25,705.70 |
| Net return/Profit (Birr/Ha.) (NP) | 62,931.90 | 20,267.70 | 53,956.90 | 69,051.00 | -5,562.50 | 67,707.80 | -6,431.00 | 19,237.10 | -33,732.50 | -24,623.70 |
| Gross Margin (TR - TVC) (Birr/Ha.) (GM) | 68,676.40 | 30,205.70 | 63,933.10 | 76,946.40 | 3,276.70 | 73,699.30 | 85,850.70 | 20,372.50 | -26,000.90 | -14,685.40 |
| Profit Margin (GM/TR) x 100 (PM) | 72.20 | 27.20 | 64.70 | 82.70 | 9.90 | 72.90 | 53.30 | 32.60 | -88.00 | -57.10 |
| Benefit Cost Ratio (TR/TC) | 2.96 | 1.22 | 2.20 | 3.88 | 0.86 | 3.03 | 0.96 | 1.44 | 0.47 | 0.51 |
| Break-even price (TC/yield) (Birr/Kg) | 35.80 | 60.50 | 21.60 | 10.30 | 60.10 | 14.90 | 87.20 | 56.90 | 119.60 | 100.70 |
| Break-even yield (TC/Sales price) (Kg/Ha.) | 407.70 | 1,288.80 | 833.00 | 314.60 | 599.70 | 403.30 | 2,009.80 | 721.60 | 1,413.00 | 1,052.90 |

## Cost-benefit and break-even analysis of basic seed production

Results of basic seed cost of production and profitability for tef, wheat, barley, maize, and faba bean are depicted in Table 3. Comparisons between research institutes and public seed enterprises are available only for tef wheat, and maize. The cost of production of basic seed of tef per unit area was relatively higher for public seed enterprises. However, the unit cost of production per kg of seed was about 31 % of that of research institutes. Hence, the net return to investment on tef basic seed production by public seed enterprises was more than seven-fold that of research institutes.

As expected, the cost of basic seed production for wheat by research institutes was about double that of the public seed enterprises (Table 3). However, the cost per kg of basic seed of wheat was six times lower than that of public seed enterprises. This was also reflected in the net return to investment and the gross margins. The gross margin of wheat basic seed production by research institutes was more than three-fold that of public seed enterprises. It is surprising why the basic seed production was more profitable for the research institutes while the larger quantity of the same seed class is produced by the public seed enterprises. The benefit-to-cost ratio was 1.71 for research institutes and 1.39 for public seed enterprises.
Maize basic seed production by research institutes was more costly as compared to that of public seed enterprises (Table 3). The total cost of production of maize basic seed was 1.5 times higher than that of public seed enterprises. The study showed that basic seed production by research institutes is at loss. The gross margin of public seed enterprises was 17 times better than that of research institutes.

In barley and faba bean basic seed production, there was no data for research institute at the time of the study (Table 3). However, the public seed enterprises had reported profit margin of 66.1% for barley and a loss of 36.1% for faba bean basic seed production. Accordingly, the benefit-to-cost ratio was 2.28 for barley basic seed production and 0.56 for faba bean basic seed production by public seed enterprises. Faba bean basic seed production was not profitable to the public seed enterprises.

The break-even prices and break-even yield for basic seed production were compared between public seed enterprises and research institutes for tef, wheat, and maize (Table 3). The break-even prices for tef and maize was higher for research institutes than for public seed enterprises. However, the break-even yield for research institutes was lower for tef while it was higher for wheat and maize as compared to that of public seed enterprises. In public seed enterprises, the break-even yield for barley and faba bean were 479.6 kg/ha and 956.2 kg/ha, respectively, while the break-even prices were 83.1 Birr/kg and 17.9 Kg/ha.

Table 3. Cost-benefit and break-even analysis of basic seed production in tef, wheat, barley, maize, and faba bean by public seed producers in Ethiopia

| Item description | Tef | | Wheat | | Barley | | Maize | | Faba bean | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise | Research Institute | Public Seed Enterprise |
| Seed yield (Kg/Ha.) (Y) | 393.00 | 1,352.80 | 2,140.00 | 1,118.30 | NA | 2,108.90 | 904.90 | 2,241.70 | NA | 500.00 |
| Sales Price (Birr/Kg) (P) | 70.40 | 64.00 | 41.50 | 66.40 | NA | 78.60 | 60.00 | 57.80 | NA | 43.50 |
| Material cost (Birr/Ha.) (MC) | 6,441.10 | 3,741.10 | 13,065.00 | 11,451.30 | NA | 17,086.10 | 10,472.80 | 7,390.70 | NA | 9,282.50 |
| Operational cost (Birr/Ha.) (OC) | 24,445.60 | 29,285.90 | 27,299.50 | 14,454.80 | NA | 12,050.40 | 40,271.20 | 31,490.20 | NA | 22,324.60 |
| Total Variable Costs (Birr/Ha.) (TVC) | 30,886.60 | 33,027.00 | 40,364.50 | 25,906.20 | NA | 29,136.50 | 50,744.00 | 38,880.90 | NA | 31,607.10 |
| Total Fixed Costs (Birr/Ha.) (F) | 8,501.40 | 9,938.40 | 23,183.10 | 7,248.10 | NA | 8,532.20 | 11,288.00 | 6,935.90 | NA | 9,938.40 |
| Total Costs (Birr/Ha.) (TC) | 39,388.10 | 42,965.40 | 63,547.60 | 33,154.20 | NA | 37,668.70 | 62,032.00 | 45,816.80 | NA | 41,545.40 |
| Unit Cost (Birr/ Kg) (UC) | 100.02 | 31.76 | 4.75 | 29.65 | NA | 17.86 | 68.55 | 20.44 | NA | 83.09 |
| Total Revenue (Birr/Ha.) (TR) | 46,021.80 | 93,140.10 | 108,713.40 | 46,169.90 | NA | 85,988.80 | 56,214.80 | 133,972.50 | NA | 23,220.80 |
| Net return/Profit (Birr/Ha.) (NP) | 6,633.70 | 50,174.70 | 45,165.80 | 13,015.60 | NA | 48,320.10 | -5,817.30 | 88,155.70 | NA | -18,324.60 |
| Gross Margin (TR - TVC) (Birr/Ha.) (GM) | 15,135.20 | 60,113.10 | 68,348.90 | 20,263.70 | NA | 56,852.30 | 5,470.80 | 95,091.60 | NA | -8,386.20 |
| Profit Margin (GM/TR) x 100 (PM) | 32.90 | 64.50 | 62.90 | 43.90 | NA | 66.10 | 9.70 | 71.00 | NA | -36.10 |
| Benefit Cost Ratio (TR/TC) | 1.17 | 2.17 | 1.71 | 1.39 | NA | 2.28 | 0.91 | 2.92 | NA | 0.56 |
| Break-even price (TC/yield) (Birr/Kg) | 100.20 | 31.80 | 29.70 | 29.60 | NA | 17.90 | 68.50 | 20.40 | NA | 83.10 |
| Break-even yield (TC/Sales price) (Kg/Ha.) | 559.50 | 671.30 | 1,530.00 | 499.70 | NA | 479.60 | 1,033.90 | 792.40 | NA | 956.20 |

## Sensitivity analysis

### Gross margin sensitivity of pre-basic seed production

Results of gross margin sensitivity analyses in terms of changes in seed price, total variable cost, and seed yield are depicted in Figures 1 (A-F). A 20% increase in seed price showed a positive gross margin while the reduction in seed price by 20% resulted in a negative gross margin in all crops except for tef produced by public seed enterprises (Figures 1A and 1D). However, the gross margin of wheat and barley was less sensitive to changes in seed price at public seed enterprises compared to that of research institutes.

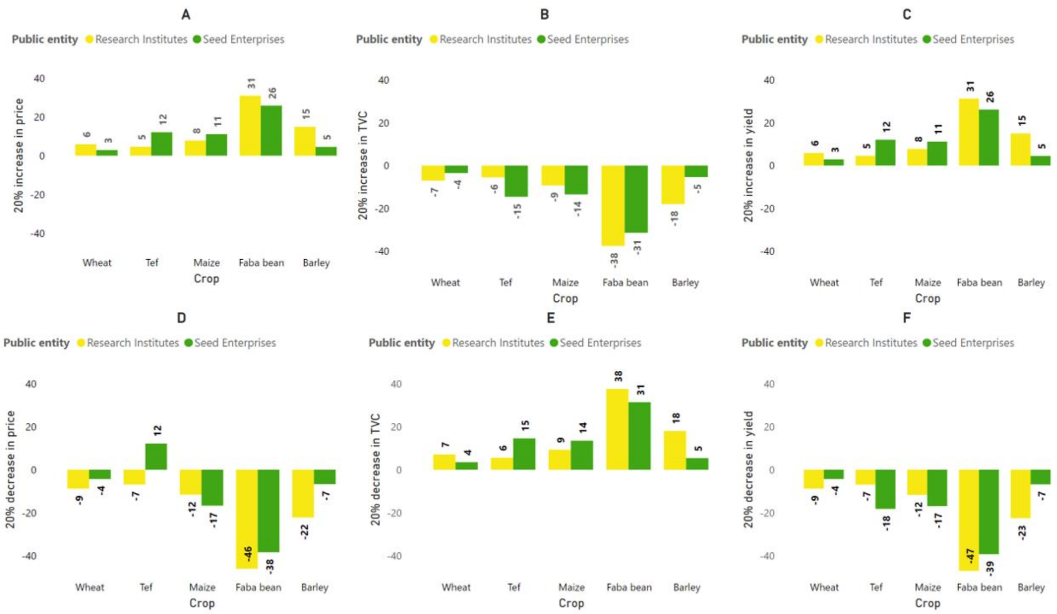


Figure 1. Percentage change in gross margin in response to changes in seed price, total variable cost, and seed yield of wheat, tef, maize, faba bean, and barley pre-basic seed production by research institutes and public seed enterprises in Ethiopia.

A 20% change in the total variable cost of pre-basic seed production changed gross margin by 4% to 38% (Figure 1B and 1E). The percentage decrease in gross margin due to an increase in total variable cost was higher for faba bean compared to other crops, both in research institutes and public seed enterprises. The gross margin of wheat and barley pre-basic seed production by public seed enterprises was less sensitive to changes in total variable cost compared to that of research institutes. The rate of increase in gross margin of faba bean due to price increase was about 31% in research institutes while the increase was 26% in public seed enterprises.

Gross margin sensitivity to changes in pre-basic seed yield is depicted in Figures 1C and 1F. Percentage changes in gross margin in response to a 20% change in yield were similar to that of changes in seed price. The gross margin of faba bean pre-basic seed production was the most sensitive to changes in seed yield both in research institutes and public seed enterprises. Response of gross margin of wheat and tef pre-basic seed production to 20% changes in seed yield was below 10% in research institutes. The gross margins of wheat, faba bean, and barley pre-basic seed production by public seed enterprises were less sensitive compared to the research institutes.

## Gross margin sensitivity of basic seed production

The sensitivity of the gross margin of basic seed production by research institutes and public seed enterprises in terms of changes in seed price, total variable cost, and seed yield is depicted in Figures 2 (A-F). The research institutes did not report basic seed production at the time of this study for faba bean and barley. A 20% increase in seed price showed a positive gross margin while the reduction in seed price by 20% resulted in a negative gross margin in all crops (Figure 1A and 1D). In research institutes, the gross margin of wheat basic seed production was more sensitive to price change while that of tef and maize was more sensitive compared to that of public seed enterprises. The response of the gross margin of basic seed production to changes in total variable cost and yield followed trends similar to that of price variation.

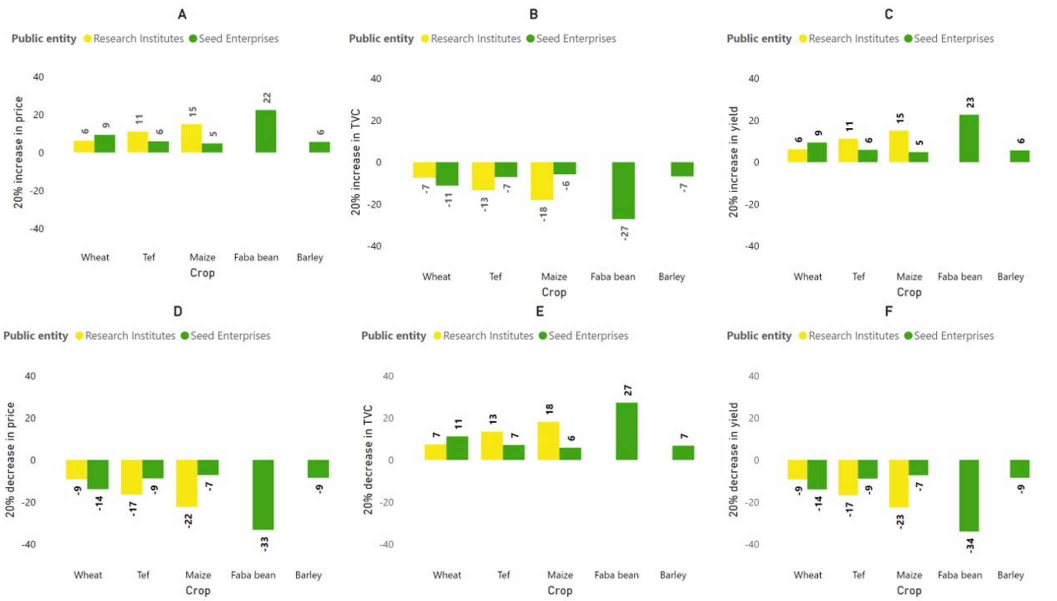


Figure 2. Percentage change in gross margin in response to changes in seed price, total variable cost, and seed yield of wheat, tef, maize, faba bean, and barley basic seed production by research institutes and public seed enterprises in Ethiopia.

## Discussion

Understanding the cost of production of early generation seed (EGS) at public seed enterprises and research institutes in Ethiopia can help to better understand the need for greater specialization in terms of the crop type and the seed class. Besides, it will be helpful to establish a practical seed pricing which is based on the cost of production. It is well documented that specialization and scale of production are important in reducing cost of production in agriculture (Chavas, 2008; Duffy, 2009).

The present study showed that the cost of production of barley and wheat pre-basic seed was higher at research institutes than at public seed enterprises. This could be attributed to lower seed yield at research centers. Seed yield of barley pre-basic seed at research institutes was 645.1kg per ha while that of public seed enterprises was 2240kg per ha. Likewise, the wheat seed yield at research institutes was 2082.4kg per ha while that in public seed enterprises was 2320.9kg per ha. The reasons for low productivity at research institutes can be attributed to a limited specialization as the major focus of at research institutes is on development of new technologies and generation of information (Bechere, 2007). Currently, the early generation seed production lacks business orientation in the research system (Kalsa et al., 2021). Establishment of business wings for early generation seed production may enhance specialization (Duffy, 2009) and improve productivity which in turn can reduce cost of production (Chavas, 2008) at the research institutes in Ethiopia.

Production of seed of maize parental lines is mostly handled by the breeding institutions in Ethiopia while public and private seed producers are also having the access to lines (Kalsa et al., 2021). The present study showed that maize pre-basic seed yield at research institutes is better than that of public enterprise. However, the cost of maize pre-basic seed production is higher at research institutes. This result could be attributed to the higher total variable cost which is driven by the high wage required to protect large number of parental materials from wild animals. A large number labor force is employed (for example at Bako National Maize Research Center) to protect maize parental lines from damages by monkeys (authors' observation). Contrary to this, public seed enterprises deal with a few numbers of parental materials which reduces the operational cost in terms of guarding. Increasing labor productivity or looking for technological options to protect parental materials from attacks from wild animal may reduce the cost of production of maize parental materials by research institute. It is already documented that enhancing labor productivity and increasing technological applications in agriculture can enhance profitability (Chavas, 2008; Duffy, 2009). The other option could be transfer of maize parental lines through open bids to capable public or private seed enterprises so that each seed producer may handle a few numbers of parental lines to easily handle. Research institutes in Ethiopia may not have the resources and structural set up to establish their own sales organization hence, they may use out-licensing to fully exploit the potential of their breeding programs like that in other countries (New Market Lab, 2020).

Both public seed enterprises and research institutes are expected to produce faba bean early generation seed for two reasons: one is to rotate their seed fields following appropriate agronomic recommendation, and second is to supply demands for improved varieties. The key agronomic benefits of faba bean are its ability to fix atmospheric nitrogen and its role in crop rotations (De Notaris et al., 2023; Köpke and Nemecek, 2010). However, faba bean pre-basic seed production is not attractive to both research institutes and public seed enterprises in terms of economic return. With the increasing need for sustainable intensification (De Notaris et al., 2023) and the need for supply of nutrient dense crops in the country (Baye et al., 2019), the early generation seed supply for this crop should be given due attention regardless of its economic return. Besides, both the research institutes and public seed enterprises should work towards increasing the yield. The average yield at research institutes was 529.3 kg/ha while that of public enterprises was 500kg/ha. In both cases, the yield is by far below the break-even yield as well as seed yield of faba bean varieties reported in the literature (Mitiku and Wolde, 2015).

# Conclusion and Recommendations

## Conclusions

This study was conducted to assess the costs of EGS production for three seed classes of the selected five crops (tef, wheat, barley, maize, and faba bean) and formulating recommendations for improving the EGS production and marketing and to contribute to the seed sector development. The results showed variations in production costs and profitability between research institutes and public seed enterprises for the same crop and seed class. Our study showed that all public producers are profitable for tef and wheat pre-basic and basic seed production, although variations observed among them. The profitability was higher for research institutes on pre-basic seed production and for public seed enterprises on basic seed production of tef. Barley pre-basic seed production was not profitable for research institutes while both pre-basic and basic seed production was profitable for public seed enterprises. Pre-basic and basic maize seed production were profitable for both research institutes and public seed enterprises. However, faba bean EGS production was non-profitable both for research institutes and public seed enterprises. Faba bean is, however, important in the crop rotation program of the seed producers. These variations might be attributed to differences among producers in terms of management capacities, infrastructure availability, technical capabilities, and business orientations.

## Recommendations

The following points are suggested to improve the profitability EGS production and its sustainable availability for the seed systems of the crops investigated:

- Under Ethiopian context, EGS production by research institutes and public seed enterprises can be profitable and sustainable with few exceptions.
- A sustainable business model archetype for each crop and each producer should be identified.
- Research institutes invest their resources in tef pre-basic seed production and public seed enterprises for tef basic seed production because the larger area required for basic seed production can well align with the high fuel consumption and machinery maintenance costs observed at public seed enterprises.
- Research institutes may have to reduce their investment on barley EGS production and support the public seed enterprises to sustainably supply EGS of barley. Besides, future studies may consider the role of malt factories on the profitability of malt barley EGS production.
- As faba bean EGS production is not profitable for both public seed enterprises and the research institutes based on the current cost-benefit analysis, the role of the crop in terms of yield increase on the subsequent crops should be considered in a future analysis.

However, the present study has a limitation as it is one-time cross-sectional study and has not considered important cost components such as the cost of rejected seed.

## Acknowledgments

We would like to thank the Ethiopian Institute of Agricultural Research and GIZ-Supporting Sustainable Agricultural Productivity in Ethiopia (SSAP) for their financial support for this research. We are also grateful to the participants of public seed producers who provided the necessary information in the study area.

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