Economics of Early Generation Seed Production in Ethiopian

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Abstract

Improving effectiveness and efficiency of the seed system is key to catalyzing agricultural transformation. The aim of this study was to generate information on cost structure, cost effectiveness of resource use, and feasibility of early generation seed (EGS) production as a business. Primary production cost and revenue data were collected for selected cereals, pulses and vegetable crops. Total cost, revenue, gross margin, profit margin, benefit-cost ratios (BCRs) and sensitivity analysis were calculated to present the data. The study revealed that labor requirement and related costs were large for most crops in consideration. The implication is that the use of cost-minimizing or labor-saving technologies are critical in seed production to minimize production costs and improve productivity. We found positive net benefit and the BCRs were greater than one for maize, wheat, common bean, soyabean and onion confirming the profitability of participating in EGS production of these crops. In general, creating a conducive working environment and encouraging private producers' participation in EGS production is important to improve smallholder farmers' access to improved seed. Improving labor use efficiency and crop productivity are also important to maximize profitability. Finally, the cost record keeping should be institutionalized in the research system for better decision-making using time series data for accuracy.

Keywords: Early generation seed, resource use efficiency, production costs, productivity, and profitability

Introduction

Ethiopian agriculture is dominated by smallholder farming where about 90% of farming is less than one hectare (Rapsomanikis, 2015). Crop production which accounts for about 65.1% of agricultural production (NBI, 2022) is characterized by low productivity mainly attributed to limited use of improved seeds and associated t echnologies. Generation and promotion of agricultural technologies are among the key factors to facilitate agricultural development process. Seed is a key input in crop production and the availability of improved and quality seed is crucial to increase crop productivity in the country (Atilaw et al., 2016). Hence, improving the effectiveness of the seed system is key to catalyse agricultural transformation and improve the availability of improved crop varieties to the farming community on a sustainable basis, in the required quantity, quality, time, and affordable prices (Ministry of Agriculture, 2013).

However, most farmers have limited access to quality and improved seed in Ethiopia (Ministry of Agriculture, 2013). According to FAO (2018), only 21% of households use improved seeds. Availability of required quality and quantity early generation seed (EGS) such as breeder, pre-basic, and basic seeds have been identified as one of the major constraints of the national seed system (Atilaw et al., 2016). Multiplication of the EGS is mainly carried out by the research centers where the variety has been released and registered. Following the multiplication of the EGS, both informal and formal seed systems can play important roles in the multiplication and distribution of seeds. Informal seed system in the Ethiopia context involves seed production and distribution by different actors with no authorized certification process (Dawit, 2010). This includes seed retained by the farmers, cooperatives/unions, farmer-to-farmer seed exchange, sales in local markets specifically the self-pollinated varieties for cash and Non-Governmental Organizations (NGO) based seed production and distribution. On the other hand, the formal seed system involves the production and distribution of seeds by the research systems or certified entities such as the national and regional seed enterprises as well as certified private seed companies along with other actors involved in the production, distribution, and regulatory activities. Nonetheless, the formal seed system is dominated by few cereal crops (mainly wheat and maize) due to commercial interest of various actors, perceived productivity gains and availability of improved varieties.

Thus, transforming the seed sector calls for policy attention to improve the availability of EGS through appropriate intervention strategies. To this end, the government has shown strong desire and commitment in supporting the research and breeding programs which are involved in the production and supply of EGS. Yet, there is a huge rift between the demand and supply of EGS and hence, the research system is under serious pressure from the demand coming from various stakeholders. On the other hand, the research system is facing serious challenges due to the limited availability of basic resources (especially, land) required for seed production.

Accordingly, different strategies should be designed to respond to the growing demand for the EGS supply. One possible way out, in the short run, is improving the productivity and efficiency of available resources including labor and land. Furthermore, engaging private investors that can fulfil the technical and other (e.g., capital) requirements in the production and supply of EGS can be another alternative to ensure sufficient supply. Whether research should improve its production efficiency on available resources or give way for other actors to involve, it is necessary to understand the cost structure and/or per unit cost of producing EGS. As EGS production and dissemination is key to accelerate the diffusion of new varieties, no study has evaluated its profitability. Particularly the introduction of new actors in this business requires proper understanding of feasibility and potential return on investment. EGS production is mainly the role of public research institutions which are not profit-oriented, and there is almost no organized information on cost of producing pre-basic seeds. The investment decision made by private companies for seed production and distribution is mainly guided by the economic profitability at large. This study is, therefore, aimed at filling information gap and thereby provide insight into the cost structure, possibility for better efficiency and feasibility for potential actors to engage in the seed business.

Research Method

Study areas, sampling, and data collection

Crops and research centres were selected purposively (Table 1) based on the importance of the crops as a strategic food security and cash crops, and responsibility of research centres in executing and coordinating centres of research and development efforts. Data were collected for the selected major cereals, legumes and vegetable crops in the respective research centres (Table 1). Cereals considered include maize, tef, wheat, barley, and rice while legume crops were common bean, soya bean, faba bean and chick pea. Data collection schedules were purposively aligned with the field operational schedule of Technology Multiplication and Seed Research Units (TMSRUs) of the respective implementing centres so that the data could be collected directly (on spot) at the time of the necessary field (farm) operations. Trials were established on a minimum of 0.25 hectare (ha) for each crop variety to allow for machinery operations. Detailed data were collected directly parallelly with field operatins. All production costs incurred from land preparation to harvesting and post-harvest handling were collected using data collection sheet developed in consultation with experienced TMSRU researchers. Training was organized for the TMSU team members and data collectors on data collection method. The research team (assigned personnel) collected all costs on the area allocated for the respective commodity.

The TMSRUs of the respective centres were responsible for the overall planning and management of the farm management processes and operations. The collected data include both direct production costs i.e., cost of seed, fertilizer, and chemicals; operation costs such as labor, fuel, and machinery costs. Opportunity costs of non-purchased inputs (e.g land) were also considered for the analysis using the real land rental value in the vicinities of respective research centres. Similar procedure was followed to estimate costs of machineries the respective farm operation. Disaggregated labor costs were collected to identify tasks that require more labor to provide insight for management decisions. Local wage rates of the respective commodity, operations and locations were considered in calculating the labor cost of EGS production in study areas and multiplied by person day. Revenues were computed only for the total value of seed produced excluding grain/rejected seeds and straw/stalk value.

Table 1: Data collection centers by crop type

Commodity	Name of varieties	Seed class	Implementing research centre (trial sites)
Cereals			
Maize	CML395	Pre-basic	Bako National Maize Research Centre (BARC)
	Melakssa-2	Pre-basic	Melkassa Agricultural Research Centre (MARC)
Tef	Boset	Pre-basic	Debre Zeit Agricultural Research Centre (DZARC)
Wheat	Ogolcho	Pre-basic	Kulumsa Agricultural Research Centre (KARC)
Wheat	Ogolcho	Pre-basic	Holeta Agricultural Research Centre (HARC)
Barely	BH-1307	Pre-basic	HARC
Rice	Shaga	Pre-basic	Fogera Agricultural Research Centre (FARC)
Legumes			
Soya bean	Belesa-95	Pre-basic	Pawe Agricultural Research Centre (PARC)
Common bean	Awash-2	Pre-basic	MARC
Chick pea	Arerty	Pre-basic	DZARC
Faba bean	Gebelicho	Pre-basic	HARC
Faba bean	Numan	Pre-basic	KARC
Vegetable (onion)			
Onion	Robaf and Nafis [1]varieties	Pre-basic	MARC

[1] Average costs and revenues of the two varieties considered.

Data analysis approach

The data were analysed using descriptive statistics and budgeting techniques (gross margin, cost-benefit ratio (CBR), break-even analysis and sensitivity analysis). All costs and benefits were converted to a hectare (ha) level. Since the marketing took place at research centres, costs of marketing were not included. Percentages were used to analyse the share of each cost item in the total variable costs. Revenue was calculated using quantity of pre-basic and the price set by Ministry of Agriculture (equation 1). In addition, Gross Margin analysis (equation 2), benefit cost ratio (equation 3), and break-even analysis (equation 4) were calculated.
Total Revenue (TR), Gross Margin (GM) and Break-Even Point (BEP) were calculated using the following formula (Mimra et al., 2019):

$$\mathrm{TR} = \mathrm{PXQ} \qquad (1)$$

$$GP = TR - TC \qquad (2)$$

$$GP = \left(\frac{TR - TC}{TR}\right) * 100 \qquad (3)$$

BEP is the variant of equation 2 i.e., when GP=0 (there would no profit or no loss) (4)
Companies can maximize the break-even point by selling above the break-even point and minimize losses by considering the margin of safety and contribution margin.
Benefit-Cost Analysis (BCA) was also done using the following equation (James and Predo, 2015):

$$\mathrm{BCR} = \frac{\mathrm{TR}}{\mathrm{TC}} \qquad (5)$$

Finally, sensitivity analysis was undertaken to assess the profitability of EGS to changing production or market conditions. The sensitivity analysis can be done by changing the seed yields and sale prices to a lower or higher level considering the likely scenarios in the future. The sensitivity is calculated to explore the impact of price and yield on the profit margin and benefit-cost ratios of the different EGS commodities considered in the study.

Results and Discussion

The results and discussion part presents the inputs and costs as well as revenues and benfits of cereal, legumes, and vegetable crops EGS production as presented and discussed in the chapter.

The result indicated that materials used in seed production were seed, fertilizer, land, and pesticides whereas operating costs indicating mainly labor and machine costs. Quantity of inputs used for cereals, legumes, and onion seed production are attached as appendices for further insights (Appendix17, Appendix 18, Appendix 19).

Labor requirement of EGS production by crop type

The result shows that rice, hybrid maize, OPV-maize and tef seed production labor used were higher compared to other cereals. Labor used for wheat seed production was low since land preparation, harvesting, and cleaning activities were carried out using machines. For all crop types, machine is used mainly for land preparation[2]. Labor used for ploughing and threshing are minimum across all commodities since it is mainly done by tractor. Weeding and roughing, chemical application, harvesting, threshing and land preparation required more labor in tef seed production in order of importance

(Table 2). Threshing and cleaning involve transportation, threshing, cleaning/winnowing, and packaging activities, requiring more labor for some commodities such as teff, maize and rice. For OPV-maize EGS production, research station (MARC) hired more labor as compared to private farms.

Operational costs	Tef	Wheat		Maize		Barley	Rice
		KARC	HARC	BH	MOPV		
Land preparation (land clearing and ploughing)	39	0	0.7	18	1	2	0
Row making and planting	17	0	0.4	14	28	1	25
Weeding and roughing	72	23.2	19	38	64	19	304
Chemical and fertilizer application	59	1	1.4	20	11	0	3
Harvesting	48	0	0.3	46	35	1	33
Threshing and cleaning *	46	19	0	28	84	0	169
Guarding/bird scaring	0	40	45	217	135	45	51
Total Labor	**281**	**83.2**	**67**	**381**	**357**	**68**	**585**

* Threshing and cleaning include transportation, threshing, cleaning/winnowing, and packaging activities.

Weeding, harvesting, and threshing/cleaning were activities used more labor in legumes seed production. Similar to cereals, labor-saving technologies used for legumes EGS production were also lower (Table 3). Hence, use of labor-saving pre-harvest, harvest and post-harvest technologies are important to reduce labor costs and hence, improve the performance of the TMSRUs of the respective commodity/centers.

Table 2: Labor requirement by activity for legume crops seed production (Person-day/ha)

Activities	Common bean	Soya bean	Faba bean		Chick pea
			HARC	KARC	
Land preparation (ploughing and clearing)	1	1	0	0	50
Raw making and planting	28	7	0	0	30
Weeding	64	93	45	50	98
Chemical and fertilizer application	1	5	0	3	3
Harvesting	35	99	23	23	15
Threshing and cleaning	22	25	11	60	72
Guarding	176	31	94	40	0
Total	**329**	**262**	**174**	**176**	**268**

[2] Land preparation in this case includes clearing and ploughing (multiple round ploughing).

Unlike cereals and legumes, vegetable seed production is more complex due to its high technology and labor-intensive nature (for chemical spray, frequent irrigation, multiple harvest of the crop and others). In the case of onion EGS production, irrigating the field is one of the most labor demanding activities followed by weed management and threshing and cleaning which also involves seed drying activities. As can be seen from Table 4, a total of 806 person-days were required to produce EGS of onion varieties at Melkasa.

Table 3: Labor requirement by activity for onion seed production (Person-day/ha)

Type of labor operation	Person-day
Land preparation (clearing, ploughing, and leveling)	30.5
Row making and planting	64
Fertilizer and chemical application	30.5
Watering/irrigation	348
Weed management	142.5
Harvesting	69.5
Threshing and cleaning	121
Total labor	**806**

Machine costs of EGS production by crop type

Land preparation was carried out using machinery for all commodities followed by harvest and threshing (Table 5). Most machine costs were recorded for land preparation for all crops. The highest machine cost was recorded for wheat (16,617 ETB) as compared to others as many of the operations including seed cleaning are executed by machine for the commodity. Harvesting and threshing is done simultaneously for wheat using combine harvester unlike others. Teff was threshed by combine harvester or small-scale thresher. Small threshers are used for threshing other commodities. In the case of onion, mechanization cost was incurred only for land preparation while the remaining operations were run by human labor. A total of 6,000 ETB was incurred for land preparation (two round ploughing) in onion seed production.

Table 4: Machine operation costs for cereals seed production.

Activities	Tef	Wheat		Maize		Barley	Rice
		KARC	HARC	BH	OPV		
Land preparation (ploughing and clearing)	2400	3115	3528	2560	4800	3528	3000
Row making and planting	0	1800	376	0	800	376	0
Fertilizer and chemical application	0	6300	0	0	0	0	0
Harvest/seed transportation	0	567	467	0	0	467	0
Harvesting and threshing	932.4	1593	1330	1440	1600	1330	0
Belling	3160	0	3467	0	0	346.7	0
Seed cleaning	0	3242	0	0	0	0	0
Total costs	**6492**	**16617**	**6047**	**4000**	**7200**	**6047.7**	**3000**

For many crops, machine cost was incurred for land preparation (one to two rounds of ploughing), row making, transportation, threshing and cleaning. In the case of legumes, machine operation costs were used for land preparation followed by row making (Table 6). Overall, the use of cost minimizing or labor-saving technologies (including machineries) are low in the EGS production process for cereals as well as legumes seed production except for wheat.

Table 5: Machine operation costs for legumes seed production (Costs per ha)

Activities	Common bean	Soya bean	Faba bean-HARC	Faba bean-KARC	Chick pea
Land preparation (ploughing and clearing)	4800	3908	2416	5110	2400
Row making and planting	1210	0	162	2190	0
Transporting	0	0	674	120	157
Threshing and cleaning	1100	0	1685	700	457
Total costs	**7110**	**3908**	**4937**	**8120**	**3014**

Labor cost of EGS production by crop type

The labor cost incurred for rice EGS production was the highest followed by costs for OPV-maize (MARC), Bako hybrid-maize (BH) and teff (DzARC) production. On the other side, lowest labor costs were incurred for wheat (Table 7). The reason for low labor cost in wheat seed production was due to the high use of farm machinery from land preparation to threshing.

Table 6: Labor costs for cereals seed production

Activities	Tef	Wheat		Maize		Barley	Rice
		KARC	HARC	BH	OPV		
Land preparation (ploughing and clearing)	7800	0	140	3150	250	400	0
Planting	2550	0	80	2450	4200	200	3750
Weeding	14400	812	3800	6650	12800	3800	60800
Chemical and fertilizer application	8850	35	280	3500	1650	0	450
Harvesting	12000	0	60	8050	7000	200	6600
Threshing and cleaning	11500	0	0	4900	21000	0	42250
Guarding		1527	9000	37975	20250	9000	7650
Total Labor cost	**57100**	**2374**	**13360**	**66675**	**67150**	**13600**	**121500**

For legumes, labor costs for common bean seed production were the highest (56,650 ETB) followed by Chick pea (5,630 ETB) and Soya bean (49,100 ETB) (Table 8). Compared with cereals, labor cost for legumes seed production was lower. As indicated in Table 3 above, weeding, harvesting, threshing, and guarding were the activities that required more labor in seed production.

Table 7: Labor costs for legume crops seed production

Activities	Common bean	Soya bean	Faba bean		Chick pea
			HARC	KARC	
Land preparation (ploughing and clearing)	300	200	0	0	10000
Planting	8400	1400	0	0	4500
Weeding	12800	18600	9000	2503	19600
Chemical and fertilizer application	200	1000	0	168	450
Harvesting	5250	19800	4600	1144	3750
Threshing and cleaning	3300	5000	2200	3020	18000
Guarding	26400	3100	9400	2000	0
Total labor cost	**56650**	**49100**	**25200**	**8835**	**56300**

For onion seed production, the highest labor cost incurred was for watering (irrigating the field) followed by threshing, drying, winnowing, and cleaning activities. A total of 174,850 ETB incurred for onion varieties seed production (Table 9).

Table 8: Labor costs for onion seed production

Type of labor operation	Costs
Land preparation (clearing, ploughing, and leveling)	9,150
Row making and planting	16,000
Fertilizer and chemical application	6,100
Watering/irrigation	69,600
Weed management	21,375
Harvesting	10,425
Threshing and cleaning (threshing, drying, winnowing, and cleaning)	24,200
Guarding	18,000
Total labor cost	**174,850**

As shown in Table 10, the highest cost shares (56, 73, 68 and 73%) of total cost of EGS production for tef, hybrid-maize, rice, OPV-maize, and rice, respectively, goes to labor cost. This clearly indicates that labor use efficiency needs to be improved to maximize the profit from the seed business. Land rental value and machinery cost are also important costs of production for wheat, tef, maize, barely and maize. The highest wheat seed production at KARC was the cost of land rental value (44%) followed by machinery costs (26%) of the total costs with similar scenario at HARC with the cost share of 38 and 25% for land rental value and labor costs, respectively. The cost of pesticides on OPV-maize was higher in MARC due to the infestation of American Fall Armyworm (AFW). Overall, labor costs, land rental value, and machine costs were important costs in cereals EGS production (Table 10).

Table 9: Summary of cereals seed productions costs

Major input used	Tef	Wheat		Maize		Barley	Rice
		KARC	HARC	BH	OPV		
Seed	1219	3525	3455	1267	750	1801	2789
Fertilizer (NPS + urea))	4254	4134	3581	4484	2208	1553	7247
Pesticides*	2250	2749	207	1855	8058	533	0
Labor	57100	2374	13360	66675	67150	13600	121500
Land (rental value)	27000	28000	20000	6000	10000	10000	28000
Machinery costs	6492	16617	6047	4000	7200	6047	3000
Internal supervision cost	3938	5479	5479	5630	2315	3938	3100
External seed inspection cost	270	145	250	250	265	250	400
Miscellaneous	230	1147	435	925	733	415	160
Total cost	**102753**	**64170**	**52814**	**91086**	**98679**	**38137**	**166196**

Similar to cereals, cost shares of material and operational costs were calculated for legumes (Table 11). Accordingly, labor, rental value of land and machine costs were the major costs recorded in soya bean (PARC), common bean (MARC), and chick pea (DZARC) with the cost share of 77, 68 and 61% respectively, while rental value of land and machine costs were also important cost components. Machinery cost was found to be higher for faba bean in KARC. Threshing takes the highest share of labor cost in common bean EGS production in MARC followed by weeding and harvesting.

Table 10: Summary of legumes seed productions costs

Major input used	Common bean	Soya Bean	Faba Bean		Chick pea
			HARC	KARC	
Seed	2549	1500	7687	9980	6115
Fertilizer (NPS + urea))	1436	1800	2632	1388	0
Pesticides*	773	0	2200	1445	1131
Labor	56650	49100	25200	8835	56300
Land	10000	2500	10000	10000	20000
Machinery costs	7200	3908	4937	8000	3013
Internal supervision cost	3431	3200	5479	5479	4718
External seed inspection cost	265	260	250	145	205
Miscellaneous expenses	468	1480	334	123	169
Total cost	**82772**	**63748**	**58719**	**45395**	**91651**

In onion seed production, labor cost takes the highest share (55%) followed by costs of seed procurement (15%) (Table 12). The third cost component was the cost of land (land with access to irrigation) for one cropping season. In MARC vicinity, the land rental value for such land was 28,000 ETB per ha in 2021 production season.

Table 12: Summary of onion seed productions costs

Cost items	Costs
Seed cost	46832.58
Fertilizer (NPS + urea))	18099.54
Pesticides	18492.65
Labor	174,850.00
Machinery costs	6000.00
Land (rental value)	28000
Internal supervision cost	21788.77
External seed inspection cost	555.00
Miscellaneous	3180.00
Total cost	**317798.54**

Profitability of EGS Production

As indicated below, net income, profit margin and BCR of EGS production were calculated for cereals, legumes, and vegetable crop (onion). Revenue was computed as a total value of seed. As it can be seen in Table 13, the net income (computed as total revenue minus total costs) of cereals EGS production for wheat, and hybrid-maize were found to be positive and the BCRs were also greater than one indicating the profitability of seed business of the commodities. This could encourage private producers/investors to be part of the seed production system in the country. The BCR for OPV-maize at MARC, barely and tef were found to be less than one which is associated with the low yield obtained during the trial year. Likewise, the BCR of rice was found to be less than one which could be due to higher cost of production.

Table 13: Comparison of revenue and costs of cereals EGS production

Item description	Tef	Wheat		Maize		Barley	Rice
		HARC	KARC	BH	OPV		
Actual seed yield (kg)	1080	2976	2169	2800	1550	713	4417
Seed price (ETB/kg)	61	46	46	83	42	30	25
Total revenue (ETB)	65880	136896	99764.8	232400	65100	21390	110425
Total costs of seed production (ETB)	102753	64170	52814	91086	98679	38137	166196
Net benefit (ETB)	-36,873	72,726	46,951	141,314	-33,579	-16,747	-55,771
BCR	0.6	2.1	1.9	2.6	0.7	0.6	0.7
BEQ (Kg)	1684	1395	1148	1097	2350	1271	6648
BEP (ETB)	95	22	24	33	64	53	38

BEQ= Break even quantity, BEP = Breake even price

Cost of chemicals was also incurred in MARC for OPV-maize due to the infestation of Fall Army Worm (FAW) during the season. The result indicates the OPV-maize productivity need to be beyond 2350 kgs or the sales value needs to be over 64 ETB/kg. Similarly, the BEQ (Kg) indicated that the enterprises are expected to supply over 1684, 1271 and 6648 Kg of teff, barely and rice, respectively or sale at BEP of 95, 53 and 38 ETB per kg accordingly for greater profitability. A study conducted in central Ethiopia reported the profitability of teff seed production under lead farmers' management condition which contrasts with this study (Tittonell, 2020; Chanyalew et al., 2019). Yazie (2021) reported the profitability of Malt barely community-based seed production in Northern Amhara region which contrasts with our finding.

The production costs and benefits of producing EGS of legume crops were also calculated (Table 14). The net benefit from common bean seed production was 52,687 at MARC. Similar study conducted in Kenya reported that, farmer based common seed production was profitable (Crop et al., 2011). BCR of Soya bean EGS production was also greater than one indicating that participation in the business is profitable. Contrarily, the BCR for faba bean and chick pea were lower than one showing negative net return.

Table 11: Comparison of revenue and costs of legumes EGS production

Item description	Common bean	Soya Bean	Faba Bean		Chick pea
			HARC	KARC	
Seed yield (kg)	3,350	2,300	425.8	377.5	970
Seed price (ETB/kg)	39.5	36.7	49.0	49.0	59.1
Seed revenue (ETB)	132,459	84,295	20864.2	18,497.5	57,356.1
Costs of seed production (ETB)	82,772	63,748	58,719	45,395	91,651
Net benefit (ETB)	52,687	24,007	(37,854.8)	(26,898)	(34,295)
BCR	1.60	1.32	0.36	0.41	0.63
BEQ (Kg)	2020	1737	1198	926	1551
BEP (ETB)	24	28	138	120	94

The possible explanation for a negative net benefit was due to the lower productivity caused by diseases pressure during the study period. For faba bean (both at HARC and KARC) and chick pea (DzARC), the net benefit would be positive if the productivity of Faba bean is increased beyond the BEQ (kg) of 1198 and 926 Kg at HARC and KARC, respectively. Similarly, the productivity of Chick pea needs to be above the BEQ (1551 Kg) for DzARC to achieve profitability. A study conducted in North Amhara region reported the profitability of community-based chick pea seed production (Chanie, 2021).

Production costs and benefits of producing EGS of onion variety (Robaf) was also carried out at MARC (Table 15). Pre-basic seed of Robaf variety was produced at MARC station. The net benefit was 1,128,391 ETB. As it can be seen in Table 15, the return to investment to onion seed production was found to be promising and attractive to private seed growers/companies.

Table 15: Comparison of revenue and costs of onion EGS production

Item description	Revenue/costs
Seed yield (kg)	615.40
Seed price (ETR/kg)	2,350.00
Seed revenue (ETB)	1,446,190.00
Costs of seed production (ETB)	317,798.54
Net income (ETB)	1,128,391.00
BCR	4.60
BEQ (Kg)	135
BEP(ETB)	516

Sensitivity analysis

Seed yields and price volatility can be two fundamental risks for operating in early generation seed (EGS) business. Sensitivity analysis of profit margins for EGS seed yields and prices of cereals, legumes and onion were conducted to capture possible scenarios in the future.

Table 16 shows the sensitivity analysis of EGS production for selected cereals and legumes across EIAR research centers. The results show that the profit margin (profit as % of total revenue) is highly sensitive to changes in prices rather than the changes in yield in most of the cases except for the wheat EGS production at HARC. Therefore, a 25% decrease in price would cause a significant profit loss from EGS production albeit the magnitude of loss varies across the various commodities and the seed types (Hybrid seed or open pollinated seeds).

For example, a 25% decrease in price would result in a 27% decrease in profitability of wheat seed while a 20% decrease in seed yield decreases the profit of wheat EGS by about 16% under the Holetta production context. Likewise, a 25% decrease in price and a 20% decrease in seed yield decreases the profit of wheat EGS at Kulumsa area by 32% and 18%, respectively, while the profitability increases by 15% and 13% for 25% increase in price and 20% yield reduction. For the hybrid maize, a 25% decrease in price and a 20% decrease in yield decreases the profitability by about 13% and 8%, respectively. Similarly, a 25% price and 20% yield increment increase profitability by about 9% and 8% respectively. For Soya bean, a 25% price and a 20% yield reduction decreases the profitability by about 32% and 15%, respectively, while a 25% increase in price and a 20% increase of yield increases profitability by about 15% and 13%. The result is in line with a study conducted by Hagos and Bekele (2018) on cost and returns of Soya bean in Asosa zone, and similar trend is observed for the common bean which is in line with the findings of Katungi et al. (2011).

Table 16: Sensitivity analysis of profit margins for selected EGS crops yields and prices.

Item description	Actual	25% decrease in price	25% increase in price	20 % decrease in yield	20% increase in yield
Cereals					
1. Wheat **a) HARC**					
Actual seed yield (kg)	2,976	3,720	2,976	2,381	2,976
Seed price (ETR/kg	46	35	81	46	46
Total revenue (ETB)	136,896	128,340	239,568	109,517	136,896
Total costs of seed production (ETB)	64,170	64,170	64,170	64,170	64,170
Net benefit (ETB)	72,726	64,170	175,398	45,347	72,726
Profit as % of total revenue	53.13	50.00	73.21	41.41	53.13
BCR	2.1	2	3.7	1.7	2.1
b) KARC					
Actual seed yield (kg)	2,169	2,169	2,169	1,735	2,603
Seed price (ETR/kg	46	35	81	46	46
Total revenue (ETB)	99,774	74,831	174,605	79,819	119,729
Costs of seed production (ETB)	52,814	52,814	52,814	52,814	52,814
Net benefit (ETB)	46,960	22,017	121,791	27,005	66,915
Profit as % of total revenue	47.07	29.42	69.75	33.83	55.89
BCR	1.9	1.4	3.3	1.5	2.3
2. Maize (BH)					
Actual seed yield (kg)	2,800	2,800	2,800	2,240	3,360
Seed price (ETR/kg	83	62	104	83	83
Total revenue (ETB)	232,400	174,300	290,500	185,920	278,880
Costs of seed production (ETB)	91,086	91,086	91,086	91,086	91,086
Net benefit (ETB)	141,314	83,214	199,414	94,834	187,794
Profit as % of total revenue	60.81	47.74	68.65	51.01	67.34
BCR	2.6	1.9	3.2	2	3.1
Legumes					
1. Common bean					
Actual seed yield (kg)	3,350	3,350	3,350	2,680	4,020
Seed price (ETR/kg	40	28	49	40	40
Total revenue (ETB)	132,325	92,721	165,574	105,967	158,951
Costs of seed production (ETB)	82,772	82,772	82,772	82,772	82,772
Net benefit (ETB)	49,553	9,949	82,802	23,195	76,179
Profit as % of total revenue	37.45	10.73	50.01	21.89	47.93
BCR	1.6	1.1	2	1.3	1.9
2. Soyabean					
Actual seed yield (kg)	2,300	2,300	2,300	1,840	2,760
Seed price (ETR/kg	37	26	46	37	37
Total revenue (ETB)	84,410	59,110	105,340	67,528	101,292
Costs of seed production (ETB)	63,748	63,748	63,748	63,748	63,748
Net benefit (ETB)	20,662	-4,638	41,592	3,780	37,544
Profit as % of total revenue	24.48	-7.85	39.48	5.60	37.07
BCR	1.3	0.9	1.7	1.1	1.6

Conclusion and Policy Recommendations

Generation and transfer of agricultural technologies is crucial to facilitate the agricultural development of Ethiopia. Use of improved and quality seeds accompanied with appropriate management practices is essential to boost the production and productivity of the agriculture sector. This suggests the need to place emphasis on an efficient seed production system. Information on cost structure, production efficiency including use of land and other farm resources provide insights on the feasibility for potential actors (private sector, youth, or joint public-private seed production ventures) to engage in EGS production business.

The results indicate that producing EGS is a profitable enterprise except for some crops due to various reasons including diseases, poor farm management practices and inefficient use of resources such as labor. Rice, hybrid and OPV-maize and tef seed production labor requirements were higher compared to other cereals while common bean, chick pea and soya bean require more labor from legume crops. The implication is that cost minimizing or labor-saving technologies are not yet used in the process of seed production at EIAR farms. Labor requirement for wheat seed production was low since land preparation, harvesting, and cleaning activities were carried out using machines. The sensitivity analysis further showed that profit margin is highly sensitive to the decrease and increase of prices over the yield decrease or increase.

The overall results of the analysis revealed that the profitability of EGS enterprises and possibility of improving the competitiveness of EGS production can be achieved mainly by enhancing labor productivity and management practices. Although the research institutes are the major source of EGS, the lack of effective resources and cost monitoring mechanism is one of the sources of their inefficiency. Hence, the following points are worth consideration to improve the profitability of seed business. These include but not limited to:

- Minimizing EGS production costs and efficiency of resource use (labor, land, and others) is critical to increase the EGS productivity and supply in sufficient quantities and required time,
- Investment in appropriate technologies including farm machinery, irrigation and equipment are critical to improve efficiency,
- Creating conducive institutional environment and incentives (improving access to credit, transparent and efficient certification process, competitive price setting, strengthening support systems: technical capacity) to attract potential actors (private sector, youth, or joint public-private seed production ventures) to engage in EGS production business, and;
- Institutionalizing cost record keeping in the research system for better

decision-making using time series data for accuracy.

References

Atilaw, A., Alemu, D., Bishaw, Z., Kifle, T., 2016. Early generation seed production and supply in Ethiopia: Status, challenges and opportunities. Ethiop. J. Agric. Sci. 27, 99-119–119.

Chanie, Y., 2021. Profitability Analysis of Community Based Seed Production of Malt barley and Chickpea in North Western Amhara Region, Ethiopia 4, 64–76.

Chanyalew, S., Genet, Y., Assefa, K., Nigussie, D., 2019. Cost-benefit Analysis of New Tef (Eragrostis tef) Varieties under Lead Farmers ' Production Management in the Central Ethiopia Cost-benefit Analysis of New Tef (Eragrostis tef) Varieties under Lead Farmers ' Production Management in the Central Ethiop.

Dawit, A., 2010. The Political Economy of Ethiopian Cereal Seed Systems: State Control, Market Liberalisation and Decentralisation.

Hagos, A., Bekele, A., 2018. Cost and returns of soybean production in Assosa Zone of Benishangul Gumuz Region of Ethiopia. *Journal of Development and Agricultural Economics*. 10(11), 377–383. https://doi.org/10.5897/JDAE2018.0952

James, D., Predo, d C., 2015. Principles and Practice of Cost–Benefit Analysis, in: Cost-Benefit Studies of Natural Resource Management in Southeast Asia. https://doi.org/DOI 10.1007/978-981-287-393-4

Katungi, E., Karanja, D., Wozemba, D., Mutuoki, T., Rubyogo, J.C., 2011. A cost-benefit analysis of farmer based seed production for common bean in kenya. *African Crop Sci.* J. 19, 409–415.

Mimra, M., Kavka, M., Markytán, P., 2019. Evaluation of economic risks in producing winter oilseed rape. TAE 2019 - Proceeding 7th Int. Conf. Trends Agric. Eng. 2019 16, 385–390.

Ministry of Agriculture, 2013. Seed System Development Strategy 2013-2017: Vision, Systemic Challenges, And Prioritized Interventions.

Rapsomanikis, G., 2015. The economic lives of smallholder farmers. An analysis based on household data from nine countries. Rome.

Tittonell, P., 2020. Assessing resilience and adaptability in agroecological transitions. Agric. Syst. 184, 102862. https://doi.org/10.1016/j.agsy.2020.102862

Appendices

Appendix17: Inputs used in cereals seed production (per ha)

Major input used	Units/ha	Tef	Wheat		Maize		Barley	Rice
			KARC	HARC	BH	OPV		
Seed	kg	25.0	150.0	168.5	25.0	30.3	66.7	100.0
Fertilizer								
• NPS	kg	100.0	121.0	182.6	200.0	100.0	67.0	121.0
• UREA	kg	200.0	50.0	56.2	100.0	50.0	37.0	350.0
Insecticide	lit	0.0	0.0	0.0	0.0	2.0	0	0.0
Herbicide	Lit	2.0	0.5	0.5	0.0	0.0	1.3	0.0
Fungicide	lit	0.0	0.5	0.0	0.0	0.6	0.0	0.0

Appendix18: Inputs used in legumes seed production

Major input used	Units/ha	Common bean	Soya Bean	Faba Bean		Chick pea
		MARC		HARC	KARC	
Seed in kg	kg	103	75	202.3	200	140
Fertilizer						
• NPS	kg	98	100	120	0	0
• UREA	kg	0	0	56	75	0
Herbicide (Dual gold)	lit	0	0	0	1	
Seed dressing chemical	kg	0.1	0	0	0	0
Pesticide (Karate)	kg	50	0	0	0	1.3
Fungicide/rexdu	lit	0	0	1	0.13	0

Appendix129: Inputs used in onion seed production

Cost items	Unit	Quantity
Seed	Kg	3122.2
Fertilizers		
• NPS	Kg	452.5
• Urea	Kg	226.2
Insecticide	Lit	2.8
Fungicides (Lifeshow, Ridomil, Agro-laxy)	Kg	11