A Comparative Assessment of the Profitability of Improved Sorghum Varieties in Western Ethiopia

Regasa Dibaba Wake[1], Ali Mohammed Oumer[2], and Dereje Alemu[3]

[1]*Ethiopian Institute of Agricultural Research (EIAR), Ambo Agricultural Research Center, Ambo, Ethiopia.*

[2]*EIAR, Holetta Agricultural Research Center, Holetta, Ethiopia.*

[3]*EIAR, Wondogenet Agricultural Research Center, Wondogenet, Ethiopia.*

***Corresponding author e**-mail: regasadibaba@yahoo.com*

Abstract

We compared the economic profitability of the newly registered sorghum varieties and local sorghum varieties in Assosa, Bambasi, and Homosha districts of Assosa Zone. Two improved sorghum varieties (Assosa-1 and Adukara) with one local variety were evaluated on farmers' fields and research stations. The experimental design was a randomized complete block design (RCBD) with three replications implemented on three farmers selected from each district. The results showed that improved sorghum varieties, particularly Assosa-1 were profitable with economic considerations and grain yield advantages over the local variety. The total gross revenue of Ethiopian Birr (ETB) 38792, 30487 and 22109 per hectare were generated from the sale of Assosa-1, Adukara, and local sorghum grains, respectively. The average variable costs incurred were ETB 14942, 15020 and 14581 per hectare by Assosa-1, Adukara, and Local variety, respectively. The gross benefits generated by Assosa-1 and Adukara improved sorghum varieties was ETB 23,850 and 15,467 per hectare, respectively as compared to the local sorghum variety which generated ETB 7,528 per hectare. The benefit-cost ratios were 2.60, 2.03, and 1.52 for Assosa-1, Adukara, and local variety which imply for every ETB incurred in costs, the farmer can expect a greater benefit. The net returns by the production of improved sorghum varieties were 45.22 and 18.08 for Assosa-1 and Adukara, respectively. The break-even prices and break-even yields for which sorghum producers at no loss no profit were ETB 4.62, 4.68, and 6.27 per kg and 1245.17, 1581.05, and 1534.84 kg per hectare for Assosa-1, Adukara, and local variety, respectively. The sensitivity analysis revealed that Assosa-1 sorghum variety production is more sensitive to price reduction than to yield in the study area. Therefore, we conclude that the use of the improved sorghum varieties, particularly Assosa-1 is the most beneficial and could be profitable for sorghum-producing smallholder farmers in the area.

Introduction

New technologies are a major instrument for achieving economic development in agriculture. In the past, a lot of effort has been made to enhance the productivity of smallholder farmers through research and development. The Ethiopian Institute of Agricultural Research (EIAR) has played a substantial role in developing improved varieties and technological options that can contribute to the development of the agricultural sector. Several technologies have been generated and released for use by farmers and many successes have been registered through the widespread adoption of new technologies.

The adoption of new technologies would be more significant if they meet the criteria of appropriateness in most of their desirable characteristics (CIMMYT, 1988). This appropriateness can vary between the target groups or farm households. Assessing the suitability of new technologies in the farm context taking into consideration the reality of the wider environment is very critical for wider acceptance of the technologies and enhancing their contributions to the national economy (Barlow *et al*. 1983). These can be achieved by delivering improved varieties to farmers at scale (Lantican *et al*. 2016; Witcombe *et al*. 2016).

A continuous flow of improved and competitive crop varieties produced by the research system is a prerequisite for the replacement of old and obsolete varieties to ultimately improve crop productivity. However, delivering new varieties to farmers does not guarantee that they will necessarily be adopted. It has been shown that certain varietal attributes can lead to strong farmer preferences for adopting specific cultivars (Hossain and Jaim 2012; Walker *et al*. 2015). To meet the farmers' preferences, there is a need to provide analysis in support of resource-allocation decisions that affect resources and the expected output. This is because difficult choices are involved when resources are scarce especially for smallholder farmers. There can also be several alternatives to employ the scarce resources for investment, which justify the wise allocation of resources in the smallholder farming context.

It would be crucial to evaluate how new technologies and their associated risks may affect profitability before recommending them to farm households. This process often done during the early stages of research popularization. In this context, on-farm experiments are important because they promote knowledge and evaluation of new and unproven agricultural technologies without jeopardizing smallholder farmers' livelihoods. This would also be useful for identifying technological options that fit smallholder farmers' needs and conditions. Socioeconomic evaluations play a major role in accepting or rejecting new agricultural technologies. Therefore, ex-post (after-release) assessment of new improved crop varieties against existing farmers' scenarios is necessary.

This study would contribute to demand-driven agricultural technology innovation and market-oriented agricultural development, by identifying competitive and profitable agricultural technologies. This paper provides empirical evidence to smallholder sorghum producers for selecting alternative technologies based on the economic principles of marginal analysis and assist the researchers in decision making in the technology selection process. The study was particularly conducted to evaluate the profitability of sorghum production by identifying the cost structures, gross margin, and returns of new technologies (improved sorghum varieties) under different niche environments in the Assosa Zone of the Benishangul-Gumuz region.

Materials and Methods

The experiment was conducted during the main cropping season for two consecutive years (May 2018 to June 2020) on farmers' fields and research stations. It was carried out at the Assosa, Bambasi, and Homosha districts of Assosa Zone in Benishangul-Gumuz Regional State, and with one reference station at the Assosa Agricultural Research Center. Two improved sorghum varieties (Assosa-1 and Adukara) were compared with local variety on farmers' fields. The field experiment was laid out in a randomized complete block design (RCBD) with three replications. Sorghum was sown in rows with a spacing of 75 cm *15 cm with a gross plot area of 300 m^2. All the required management practices were done as per the recommendation.

Experiment Design

The study was designed as a pilot to generate economic information on newly released sorghum technologies (Assosa-1 and Adukara varieties) and draw lessons for scaling of new technologies. The sorghum varieties were released from the Assosa Agricultural Research Center (AsARC) for the intermediate and humid low agroecology in the western parts of Ethiopia. These newly released varieties were evaluated with local variety on farmers' fields. The trial was planted with and without a randomized complete block design with three replications. The plot area was 10 m * 10 m and seeds were drilled into 13 rows at the rate of 120 gm seeds per plot. Appropriate spacing was considered between replication, plots/blocks, rows, and plants. Hence, 50 cm space was maintained between the block and around the border of the field. NPS/DAP and Urea fertilizers were applied at the rate of 100 kg per hectare. The Urea fertilizer was applied twice in a split application. All agronomic and field operations were performed. The on-farm plots were managed jointly by the owner farmers and researchers.

Data types and collection methods

Data were collected from the field through farm records and direct observation of each farm activity. Data on land preparation, plowing, planting, field management, harvesting, threshing, and post-harvest handling were collected for selected sorghum varieties from each experimental plot and farmers' fields. Socio-economic data such as the price of inputs and outputs, operation practiced by farmers, productivity, or yield of each sorghum variety, costs that varied from sorghum varieties and farm operations (seed, labor, fertilizer, farm equipment, tillage) were recorded. All necessary costs and benefits were also recorded and standardized to the hectare level.

Data analysis

The data were analyzed by using descriptive statistics and budgeting techniques (gross margin, average farm income, break-even, and sensitivity analysis).

Descriptive statistics such as frequency and percentage were used to describe the characteristics of respondents while the mean was used as a measure of central tendency. Percentages were also used to compute the share of each cost item in the total variable costs. Gross margin was used as a proxy for the profitability of an enterprise. It is the difference between income and variable costs (Kay *et al*., 2004). The gross margin is an appropriate measure of profitability for comparing sorghum varieties for short-run decisions. Thus, the gross margin and net returns analysis were used to determine the profitability of sorghum production.

Mathematical specification

To determine the cost and returns to each sorghum variety production, the gross margin (GM) analysis was employed. The gross margin is the difference between the total revenue (TR) and the total variable cost (TVC). The total revenue is estimated as the prevailing market price of a given output multiplied by the quantity of output sold. Total variable cost is a summation of all input variable costs incurred by a given producer, and the input cost is estimated as the prevailing market price of a given input multiplied by the quantity of the input used. It is a useful planning tool in situations where fixed capital is a negligible portion of the farming enterprise in the case of smallholders' subsistence agriculture (Olukosi and Erhabor, 1988).

The total revenue of improved varieties was estimated as follows:

$$TR = \left(\sum (Q_{yi} * P_{yi})\right) \quad (1)$$

The total revenue is generated from the sale of sorghum output (kg) and its price in Ethiopian Birr (ETB). TR is the average adjusted grain yield (kg/ha) multiplied by price (farm gate price) of each sorghum variety (ETB/kg).

Gross margin (GM): Gross margin is the difference between the total return (TR) and the total variable cost (TVC). It was estimated as follows:

$$GM = \left(\sum (Q_{yi} * P_{yi})\right) - \left(\sum (Q_{xi} * P_{xi})\right)$$
$$= \mathrm{TR}_{\mathrm{yi}} - \mathrm{TVC}_{\mathrm{yi}} \quad (2)$$

where GM is the gross margin per ha for each sorghum variety, $\mathrm{TVC}_{\mathrm{yi}}$ is the total variable cost (TVC/ha) incurred to produce each variety; $\mathrm{TR}_{\mathrm{yi}}$ is the total revenue generated from each sorghum variety.

The costs of production were calculated as:

$$TVC = \left(\sum (Q_{xi} * P_{xi})\right) \quad (3)$$

where $Q_{yi}$is the quantity of sorghum output sold, P_{yi} is the price of each sorghum variety output, Q_{xi} is the quantity of input i, and P_{xi} is the price of input i used for producing each variety. The variable costs included the cost of seeds, fertilizers, agrochemicals, labors, materials, oxen draft power, and other costs.

Benefit-cost ratios of each sorghum variety have been calculated for finding the most profitable sorghum variety in terms of total and net revenue. More specifically:

$$Benefit\,\text{cost ratio} = \frac{NR_{yi}}{TC_{yi} \text{ or TVC}} \quad (4)$$

where NR is the net revenue from each sorghum variety and TC is the total cost incurred to produce each sorghum variety or TVC for the total variable cost of each sorghum variety.

Break-even analysis: Break-even analysis was used to determine the break-even yield and the break-even price at which the total receipt is equal to the total costs for each sorghum variety. It is a useful tool in enterprise analysis (Rod and Dennis, 2001). It is the point where gross margin and total variable cost (TVC) are the same or when the sales of a farm are enough to cover the expenses (variable costs). The break-even price is calculated to find out at what price an output would have to be sold in the marketplace to pay for its production. Break-even yield also shows at what production potential a product is economically feasible given the variable cost and price.

$$Break-even\,\text{yield} = \frac{TVC}{Sale\,\text{price}} \quad (5)$$

$$Break-even\,price = \frac{TVC}{Total\,\text{production}} \quad (6)$$

$$Net\,\text{Benefit} = (TR - \text{Total cost or GM - Total fixed cost}) \quad (7)$$

The total cost is given by the sum of the total fixed cost (TFC) and the TVC (Katungi *et al*, 2011).

$$\text{Net Return for improved variety} = \left(\frac{NB \text{ of Assosa-1 or Adukara - NB of Local}}{TVC \text{ of Assosa-1 or Adukara - TVC of Local}} \right) \quad (8)$$

Sensitivity Analyses: It was done by varying prices and yield conditions to compare the effect on net farm income or gross margin. It is used to identify key sources of variability and uncertainty for the variation of an expected result to make the best decisions considering future scenarios. Gross Margin can be influenced by the sales price of the outputs and yield. The sensitivity is computed to explore the effect of assumptions regarding the changes of these determinant factors on the gross margin by using the principle of "what if" scenarios (Dachin and Ursu, 2016). To determine the stability of profitability of sorghum production, the quantity of sorghum produced was subject to reduction by 15% and to increase by the same amount and new gross margins were computed. The 20% variability in the yield of sorghum and 15% of variability in the price of sorghum was observed based on the current trend of price and yield variation in the year.

Results and Discussions

Inputs used (fertilizers and seed) in sorghum production

NPS/DAP and Urea were applied at the recommended rate for sorghum production. Thus, smallholder farmers applied NPS/DAP and Urea fertilizers at a rate of 100 kg/ha for sorghum production. It is recommended to apply all NPS/DAP at sowing, while Urea was applied in splits with the first half at sowing and the second top-dressed at the full tillering stage. On average, for sowing the sorghum in a row about 12 kg/ha of seed was used in the area (Table 1). On average, the total cost of fertilizers was Ethiopian birr (ETB) 1476 and 1364 per hectare in the study area for NPS/DAP and Urea, respectively. The rate and the application procedure of fertilizers was the same for improved varieties and local variety.

Table 1. Inputs used in sorghum production

Item descriptions	Unit	Mean	Minimum	Maximum	SD
Amount of NPS/DAP used	Kg/ha	100	100	100	
Price of NPS/DAP	ETB/kg	14.76	14.51	14.98	0.21
Amount of Urea used	Kg/ha	100	100	100	
Price of Urea	ETB/kg	13.64	13.38	13.90	0.23
Sorghum seed used	Kg/ha	12	12	12	
Price of local seed	ETB/kg	11	9	12	1.20
Price of improved seed	ETB/kg	24	19	26	3.10

Source: Data results, 2020; SD=Standard Deviation.

Cost of seeds for sorghum production

The average total cost per hectare for improved sorghum varieties was about ETB 285, while for the local variety was ETB 130 per hectare in the area (Table 2).

Table 2. Cost of seed for each variety

Variety	n	Mean	Minimum	Maximum	SD
Assosa-1	16	284.85	230.40	309.60	37.91
Adukara	16	284.85	230.40	309.60	37.91
Local	16	129.75	108.00	144.00	14.68
Overall	48	233.15	108.00	309.60	80.29

Source: Data results, 2020; SD=Standard Deviation.

Table 3 presents the labor engaged in the production activities. The agricultural activities are operated by manual work and animal power for various farm operations. As sorghum production is highly labour-intensive, labor is a major constraint. The availability of labor has been observed to influence farm operations such as clearing, plowing, row making, sowing, fertilizer application, hoeing, thinning, weed control, harvesting, and threshing for sorghum production and marketing. On average, about 6 male and 6 female laborers were engaged in land preparation for hectares of sorghum production.

Table 3. Labor use for different sorghum farm operations

Farm operations	Labor used for sorghum farm operations							
	Male				Female			
	Mean	Minimum	Maximum	SD	Mean	Minimum	Maximum	SD
Land preparation/clearing	6	3	12	3.19	6	6	6	
1st Ploughing	3	3	3	0	0	0	0	0
2nd Ploughing	4	3	12	2.27	5	3	6	1.5
3rd Ploughing	3	3	3	0	3	3	3	0
Agro-chemical application	0	0	0	0	0	0	0	0
Line/row making	9	6	15	1.55	0	0	0	0
Sowing/planting	8	6	12	2.40	4	3	6	1.47
Fertilizer application	8	6	12	2.10	6	3	15	3.36
Cultivation/hoeing	8	2	21	4.86	5	1	15	3.99
Thinning	11	9	15	2.39	3	3	6	1.08
Fertilizer/ Urea application	12	9	15	1.47	3	3	3	0
1st Weeding	9	3	18	4.67	6	3	12	3.29
2nd Weeding	11	3	18	4.38	7	3	15	6
3rd Weeding	13	6	18	4.63	0	0	0	0
Harvesting	12	9	15	1.30	3	3	3	0
Threshing	11	6	12	1.75	5	3	12	2.37

Source: Data results, 2020; SD=Standard Deviation.

Cost of materials used for different farm operations

The Ethiopian agricultural system is predominantly subsistence. It is characterized by using traditional farm equipment and practices. Agriculture, which constitutes a large proportion of the population, continues to use hand tools and tillage equipment for a long period. Some farming activities are done by hand without the use of hand tools, but many other activities are also done by using rudimentary hand tools or operated using animal power. The use of traditional hand tools by smallholder farmers might incur material costs when operating different farm activities on the farm. On average, smallholder farmers cost ETB 151 and 1316 per

hectare in land preparation/clearing and for plowing activities, whereas about ETB 475 and 121 per hectare for row-making and hoeing activities in sorghum production, respectively (Table 4). We estimated the material costs based on the rental value of farm tools used for different farm operations. Moreover, smallholder farmers incurred material costs for thinning, harvesting, threshing, and other farm operations in sorghum production activities. Oxen draft materials (*Maresha)* and simple hand tools like, pale, sickle, pickaxe, and hoe are the main materials used for sorghum production activities by smallholder farmers in the area. These materials cost smallholder farmers for sorghum production.

Table 4. Material cost for different farm operations

Material cost for farm operations	Costs required for materials/ equipment			
	Mean	Minimum	Maximum	SD
Land preparation/clearing	151	115	247	58.38
Plowing materials	1316	632	2111	457.58
Agro-chemical application	0	0	0	0
Line/row making	475	300	600	97.49
Sowing/planting	0	0	0	0
Fertiliser application	56	33	67	16.67
Cultivation/hoeing	121	67	233	40.13
Thinning	124	103	143	17.96
Weeding	0	0	0	0
Harvesting	126	117	139	7.60
Threshing	319	200	426	79.90

Source: Data results, 2020; SD=Standard Deviation.

Time is one of the most important factors which affect agricultural production. The time taken to produce any crop depends to a large extent on the types of field operation activities (involving land preparations, cultivations, harvesting and threshing) , available labor forces, and farm equipment engaged in the production. The working hours required for various farm operations can be achieved using suitable agricultural equipment and the existence of labor who do the primary actions i.e., clearing, plowing and row making, sowing, hoeing, weeding, harvesting, and threshing in the area. About 18 and 85 working hours for land preparation and plowing operations per hectare in sorghum production using manual and animal power, respectively. Row making, sowing, and fertilizer application were the farm operations that required working hours in sorghum production activities. Furthermore, the working hours required for farm operations vary with farm activities in the production of sorghum (Table 5). By using manual farm tools and animal power for sorghum production, we find that different farm operations required a minimum of 8 working hours for land preparation and a maximum of 125 working hours for threshing sorghum produce.[1]

[1] Manpower and animal power are measured by working hours per hectare of land. It is noted that 8 working hours are spent per day for manpower and draft animal power in the study area, which is the number of hours spent per day on farm operation activities.

Table 5. Working hours for different farm operations (per hectare)

Farm operations	Working hours required for farm operations			
	Mean	Minimum	Maximum	SD
Land preparation/clearing	18	8	27	6.92
Plowing	85	53	109	20.14
Agro-chemical application	0	0	0	0
Line/row making	58	45	93	15.24
Sowing/planting	51	43	89	10.99
Fertilizer application	52	43	97	14.73
Cultivation/hoeing	61	44	107	16.26
Thinning	66	49	95	10.01
Urea application/fertilizer	60	45	95	15.94
Weeding	68	48	106	15.38
Harvesting	64	50	102	14.10
Threshing	86	55	125	17.30

Source: Data results, 2020; SD=Standard Deviation.

Labor cost for sorghum farm operation activities

The cost of performing different farm operations include labor cost and animal power in the study area. The engagement of the labor force in the rural economy concerning agriculture is less with a lower-wage payment rate mostly around 30 to 60 ETB per day for working on-farm activities. While preparing land for plowing and cultivation by hand or animal power, around 187 ETB/ha were required for clearing operations with around 18 working hours. Meanwhile, around 484 ETB/ha had been required for sorghum farm operations by using animal-drawn power for levelling and row making, whereas for sowing sorghum seed was about 535 ETB/ha. The labor cost for different farm operations in producing sorghum required hired and family laborers considering the opportunity cost for casual labor payment rates in the areas. For fertilizer application and hoeing, about 499 and 511 ETB/ha were required for labor costs in operating sorghum production activities, respectively. The mean labor cost for thinning and second-round fertilizer application (Urea) were required around 497 and 494 ETB/ha to produce sorghum in the area. The average cost of hired labor ranged from 30 to 60 ETB per person-day based on farm activities (see Table 6).

Table 6. Wage paid for casual laborers in different farm operations (per hectare)

Farm operations	Labor cost for sorghum production			
	Mean	Minimum	Maximum	SD
Land preparation/clearing	187	75	370	99.37
Plowing	1464	844	2660	595.40
Agro-chemical application	-	-	-	-
Line/row making	484	392	583	58.33
Sowing/planting	535	383	642	63.27
Fertilizer application	992	742	1180	109.52
Cultivation/hoeing	511	300	810	121.50
Thinning	497	330	898	153.41
Weeding	1164	778	2476	479.01
Harvesting	586	512	1215	140.32
Threshing	561	471	1188	144.55

Source: Data results, 2020; SD=Standard Deviation.

Yields of each sorghum variety

Table 7 presents adjusted yields[2] of sorghum varieties in the study area. The highest mean yield was generated by the Assosa-1 variety (3233 kg/ha) followed by the Adukara variety (3209 kg/ha), and the local variety recorded around 2327 kg/ha of land. The maximum yield was obtained from the Adukara variety with 4574 kg/ha followed by Assosa-1 with 4146 kg/ha. The maximum grain yield obtained from local variety was 3910 kg/ha with the lowest yield of 530 kg/ha. Thus, a statistically highly significant yield difference was obtained at each experimental site from each variety implemented on farmers' fields and research stations.

Table 7. Adjusted yields of sorghum varieties in kg per hectare of land

Variety	n	Mean	Minimum	Maximum	SD
Assosa_1	16	3233	2244	4146	683.9
Adukara	16	3209	2393	4574	684.3
Local	16	2327	530	3910	911.8
Total	48	2923	530	4574	863.4

Source: Data results, 2020; SD=Standard Deviation.

Total operational cost for producing sorghum varieties

The estimated value of family labor and land from own use in production were considered in terms of their opportunity costs of market wages and rental values, respectively. In countries, where purchasing agricultural land hardly exists but has considerable tenancy, the rental value of land provides a good indication of the net value of production. Similarly, the opportunity cost of rural family labor measured in market wage paid during peak seasons can be accepted as the economic value of rural family labor (Gittinger, 1984). Land rental value is assigned based on the local market value of the farmland. The land rental value was ETB 2000 per hectare used for sorghum production. Using the "opportunity cost" concept, we calculate the value of land as a variable cost by the estimated local market value. The total variable (operational) cost includes seed cost, fertilizer cost, cost of oxen draft power during land preparation and planting, labor cost, and cost of other materials used for sorghum production. Thus, the total cost of sorghum production consisted of the rental value of farmland, the cost of inputs, and the cost of farm operation starting from land preparation to final marketing.[3] Thus, the average cost

[2] Actual yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same field.

[3] The total variable cost includes material cost (rental value), labor cost, oxen draft power rental cost, cost of fertilizers, seed cost, transporting cost, land rental cost, and other miscellaneous costs to produce sorghum varieties. These costs are considered as operational costs of farm activities. It should be noted that the cost of oxen draft and labor was incorporated with the whole activities required for farmland operation in the local conditions.

of operations in producing sorghum varieties was ETB 14942 per hectare for the Assosa-1 variety, whereas it was ETB 15020 per hectare to produce the Adukara variety. The average operational cost of producing local variety was ETB 14581 per hectare (Table 8).

Table 8. Total Variable Cost by each Sorghum variety

Variety	n	Mean	Minimum	Maximum	SD
Adukara	16	15020	12978	18053	1611.31
Assosa-1	16	14942	13170	17949	1546.95
Local	16	14581	12581	17195	1520.49
Total	48	14847	12581	18053	1538.66

Source: Data results, 2020; SD=Standard Deviation.

Total Revenue of Sorghum Varieties

The average gross revenue generated from each sorghum variety was presented in Table 9. The current market price for Assosa-1 was ETB 12 per kg, while the current market price for both Adukara and local sorghum varieties was ETB 9.5 per kg in the study area. The average revenue generated from sorghum production by Assosa-1, Adukara, and local varieties were estimated at ETB 38,792; 30,487, and 22,109 per hectare, respectively. Furthermore, the average gross revenue generated by Assosa-1 variety production was higher than the local variety and Adukara because of its white grain color that fetches higher market price in the area. The results showed that there is a significant difference in gross revenue generated among the sorghum varieties.

Table 9. Total revenue generated from each variety

Variety	n	Mean	Minimum	Maximum	SD
Assosa-1	16	38792	26932	49748	8206.789
Adukara	16	30487	22730	43453	6501.113
Local	16	22109	5032	37142	8661.801
Overall	48	30463	5032	49748	10310.43

Source: Data results, 2020; SD=Standard Deviation.

Cost and Returns of Sorghum Varieties

Table 10 presents the revenue and cost analysis to produce improved sorghum varieties and the local variety. The share of labor cost in total cost for different sorghum farm operations[4] contributed about 29% in a farm operation to produce improved sorghum varieties and 30% for local variety. The largest cost share to produce improved varieties and the local variety was incurred by labor costs for different farm operations followed by fertilizers and oxen power costs in the area. However, no cost is incurred for agrochemicals in the production of sorghum. The

[4] These operations include land clearing, weeding (first, second, and third wedding), fertilizer applications, hoeing, and thinning.

average cost share of fertilizers and farm tools to produce each of the improved sorghum varieties (Assosa-1 and Adukara) accounted for 19% and 14%, respectively. While the average cost share required to produce local variety was 19% for fertilizers and 15% for material cost. Furthermore, oxen draft power costs for plowing including first, second, and third plowing activities with planting and row making, took the largest share of the operational cost estimated at 17% for improved sorghum varieties and 18% in producing local sorghum variety. Moreover, the cost of farmland accounted for 13% of each of the improved sorghum varieties and 14% for producing local sorghum varieties. The share of miscellaneous costs (cost of transporting, and others) for sorghum production constitutes about 5% of the total average variable cost of production for improved sorghum varieties and only 4% in producing local sorghum varieties.

The average total variable costs to produce improved sorghum varieties of Assosa-1 and Adukara were ETB 14942 and 15020 per hectare, respectively. While the local variety required a total variable cost of ETB 14581 per hectare. The average gross revenue from producing Assosa-1 variety was ETB 38,792 per hectare and that of Adukara variety was ETB 30,487 per hectare. The production of local sorghum varieties generated revenue of ETB 22,109 per hectare. Thus, the net incomes generated by Assosa-1, Adukara, and local sorghum varieties was ETB 23,850, 15467, and 7528 per hectare/ha, respectively. This result indicates that the production of sorghum using improved varieties in the area is quite profitable. The share of each operational cost of sorghum variety was slightly varied among the cost items to produce improved varieties and local variety of sorghum crops. The net benefit generated from each sorghum variety showed a higher return due to the cost of farmland accounted as a fixed cost.

Table 10. Cost and return for improved sorghum varieties and local variety

Description of Cost and Revenue Items	Sorghum Varieties					
	Assosa-1		Adukara		Local	
	Cost per ha (ETB)	%	Cost per ha (ETB)	%	Cost per ha (ETB)	%
Cost Items						
Seed cost (ETB/ha)	285	1.91	285	1.90	130	0.89
Fertilizers cost (ETB/ha)	2839	19.00	2839	18.90	2839	19.47
Material cost (ETB/ha)	2150	14.39	2155	14.35	2137	14.66
Labor cost (ETB/ha)	4296	28.75	4329	28.82	4308	29.55
Oxen power cost (ETB/ha)	2612	17.48	2592	17.26	2597	17.81
Land rental cost (ETB/ha)	2000	13.39	2000	13.32	2000	13.72
Miscellaneous cost (ETB/ha)	760	5.09	820	5.46	570	3.91
Total cost/TVC (ETB/ha)	**14942**	**100**	**15020**	**100**	**14581**	**100**
Revenue (ETB/ha)						
Gross revenue (ETB/ha)	**38792**		**30487**		**22109**	

Source: Data results, 2020

Profitability of Sorghum Varieties

The gross margin from improved sorghum varieties could be compared with a local variety (Table 11). The result of the gross return and cost analysis of improved sorghum varieties compared to local variety showed that the gross margin of ETB 23,850 per hectare generated by Assosa-1 and ETB 15,467 per hectare by Adukara variety as compared to ETB 7,528 per hectare by the local variety. The net benefit/profit generated from improved sorghum varieties of Assosa-1 (ETB 23,850 per hectare) and Adukara (ETB 15,467 per hectare) was higher than the local variety (ETB 7,528 per hectare). The result also revealed that the net returns for improved varieties compared to the local variety were estimated to be 45.22 and 18.08 for Assosa-1 and Adukara improved sorghum varieties, respectively (Table 11).

The cost and return analysis indicated that Assosa-1 has more benefits than the Adukara improved sorghum variety and the local variety. Thus, the gross margin generated from Assosa-1 improved variety was higher compared to Adukara and local variety. This could be because of higher market prices as a result of grain color and preferred by smallholder farmers for consumption in the area. Our analysis indicates that Assosa-1 was the most profitable of all the varieties evaluated in the study area. Thus compared to local variety, improved variety (particularly Assosa-1) makes farmers better off in terms of net income-the main driver for smallholders in the Assosa Zone to take up the preference and production of Assosa-1 improved variety than the other improved and local variety of sorghum. The values of the gross margin analysis results also showed similar values for each sorghum variety.

The results of the break-even analysis indicated that the break-even price that can cover all variable costs under the current condition of production was ETB 5 per kg both for Assosa-1 and Adukara varieties; while required sale price of ETB 6 per kg to cover operating and material costs for local variety production. On the other hand, the break-even yield to cover the variable costs was about 1245 kg/ha for the Assosa-1 variety. The break-even yield to cover all variable costs was 1581 and 1535 kg/ha for Adukara and local sorghum production, respectively. Therefore, to minimize risk (loss), the smallholder farmers should produce at least a break-even yield per hectare and/or the minimum price of sorghum varieties above break-even on average price to cover the variable costs (Table 11). By producing this quantity of sorghum grain, the smallholders should face a no profit no loss situation.

Table 11. Summary of sorghum production costs and revenue

Items descriptions	Sorghum varieties		
	Assosa-1	Adukara	Local
Total revenue (TR) (ETB//ha)	38792	30487	22109
Material cost (ETB/ha)	2150	2155	2137
Labor cost (ETB/ha)	4296	4329	4308
Total Variable cost ETB/ha (TVC)	14942	15020	14581
Gross Margin/ha (GM)= (TR-TVC)	23850	15467	7528
Profit margin (%) = (NR/TR)	61.48	50.73	34.05
Benefit-cost ratio (BCR) = (TR/TVC or TC)	2.60	2.03	1.52
Net of returns by improved varieties	45.22	18.08	0
Break-even yield= (TVC/Sale price) (Kg/ha)	1245.17	1581.05	1534.84
Break-even price= (TVC/Total production) (ETB/kg)	4.62	4.68	6.27

Source: Data results, 2020

Sensitivity analysis of gross margins for sorghum varieties

Grain yield of the crop and price volatility are two fundamental risks in the farming operation of smallholders. Thus, sensitivity analysis was undertaken to assess the profitability of sorghum varieties' to changing production or market conditions. That is the grain yield and the sales price of each variety. The effect of higher or lower yields and higher or lower sales prices can be represented. The sensitivity is calculated to explore the impact of assumptions regarding the changes of these determinant factors on the gross margin, by using the principle of "what if" scenario (Dachin and Ursu, 2016).

Table 12 shows the sensitivity analysis of improved sorghum varieties and local variety gross margin for the smallholder farmers in the study area. The results show how sensitive the gross margin is to both yield and price changes compared to the variation of price ±15% change and varying grain yield ±20% in the area. Thus, a 15% decrease in price would cause about a 24% decrease in gross margin for Assosa-1 improved sorghum variety, whereas a 20% decline in yield would lead to a 33% reduction in gross margin. About a 15% increase in price would result in a 24% increase in profitability and a 20% increase in yield increases the profit of the Assosa-1 sorghum variety by 33% in the study area.

The results revealed that Assosa-1 sorghum variety production is more sensitive to price reduction than to yield reduction. Further, as the price decreased by 15% for Adukara variety production, the profitability decreases by 30%, while a 20% reduction in yield reduces the gross margin of Adukara by 39%. This implies that the production of sorghum varieties' profitability is highly sensitive to price and yield decreases in the area. Similarly, a 15% decline in the price of grain for the local sorghum variety resulted in about a 44% decrease in gross margin. The 20% decline in yield also resulted in about a 59% decrease while a 20% increase in grain yield contributed to about 59% changes in gross margin in production of the local variety. These findings are consistent with previous studies such as (Samuel *et al*., 2019) and (Getinet *et al*., 2020).

Table 12. Sensitivity Analysis for sorghum varieties with varying prices and yield

Item Descriptions	Original value	15% reduction in price	15% increase in price	20% reduction in yield	20% increase in yield
Assosa-1					
Total revenue (ETB/ha)	38792	32977	44615	31037	46555
TVC or TC (ETB/ha)	14942	14942	14942	14942	14942
Gross margin (ETB/ha)	23850	18035	29673	16095	31613
Change in gross margin (%)		-24.38	24.42	-32.52	32.55
Adukara					
Total revenue (ETB/ha)	30487	25913	35058	24388	36583
TVC or TC (ETB/ha)	15020	15020	15020	15020	15020
Gross margin (ETB/ha)	15467	10893	20038	9368	21563
Change in gross margin (%)		-29.57	29.56	-39.43	39.41
Local					
Total revenue (ETB/ha)	22109	18791	25422	17685	26528
TVC (ETB/ha)	14581	14581	14581	14581	14581
Gross margin (ETB/ha)	7528	4210	10841	3104	11947
Change in gross margin (%)		-44.08	44.02	-58.76	58.70

Source: Data results, 2020

Summary and Conclusion

Benishangul-Gumuz region is bestowed with various cash and food crops in which the region is having comparative advantages and high national competitiveness, particularly for humid and intermediate sorghum production. This study evaluated the economic profitability of new and improved sorghum varieties in comparison with the local variety. The results demonstrated high economic profitability and yield advantages for improved sorghum varieties over the local varieties. Our results suggest that promoting and producing improved sorghum variety particularly Assosa-1 was highly profitable among smallholder farmers. Therefore, Assosa-1 sorghum variety production has an acceptable and more comparative advantage than Adukara and local varieties in the study area.

Sorghum production in the Assosa zone is profitable. We recommend that farmers should have better access to improved sorghum varieties particularly the Assosa-1 variety with improved farm management and agronomic practices. There is a need to improve the pricing system of sorghum grain by encouraging farmers' groups to improve their bargaining power. Moreover, policies should be developed to enhance productivity and thereby the profitability of sorghum-producing farmers in the study area and beyond. As an important agricultural crop that is a major staple food crop in the area, promotion of improved sorghum production among farmers can increase grain yield, enhance income of smallholder farmers, and improve food security at the household and national levels.

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