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DEMONSTRATION OF IMPROVED SOYBEAN TECHNOLOGIES THROUGH LARGE- SCALE CLUSTER FARM APPROACH

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Abstract: Soybean is grown in different parts of Ethiopia; the major areas currently growing the crop are situated in the western and south-western part of the country. Oromia and Benishangul-Gumuz regions account for the highest production of soybean in the country, 51 and 40 percent respectively. So, large-scale demonstration was conducted to demonstrate improved soybean technologies towards commercialization, to enhance adoption and to strengthen research and extension linkage by engaging 11 small administrative units from Assosa and Bambasi districts. 421 men and 88 women farmers were benefited with a total gain of 497,298.2 kilogram production from 248.5 hectare land. Average yield of improved gishama soybean variety has been recorded 2001.2 kilogram per hectare with an indication of soybean crop potential maximum yield 2,400 kilogram per hectare in the area. Compared to the farmers' average yield (without full package and intensive management practice) the demonstrations fields have 726.2 kilogram per hectare yield advantage. Net benefit of birr 24,250.84 per hectare from the sale was earned. The benefit cost ratio accounted 1.84 birr. The sensitivity analysis showed the profitability of soybean production is more sensitive to reduction in yield and price as well increase in variable cost other variables remain constant. Both men and women farmers preferred gishama soybean variety because of better grain yield, tolerance to diseases, tolerance to shattering, biomass for soil fertility restoration and weed suppressing potential due to high branching nature. Large-scale demonstration approach encourages production for market and industries as well as strengthens habit of team work. Low soil fertility, lack of reasonable grain price, small plot of land allocation, high fertilizer price, lack of tractor followed by lack of thresher were the major constraints to soybean production. Hence, it is concluded gishama soybean variety production is profitable enterprise in the area. So, focus on improvement of production constraints and further scale-up of the approach are recommended in the region.

Index Terms **- Demonstration, Benefit- cost ratio, Constraints, Large –scale, soybean variety, Traits.**

I.INTRODUCTION

Soybean is grown in different parts of Ethiopia; the major areas currently growing the crop are situated in the western and south-western part of the country, notably Benishangul-Gumuz, Gambella and parts of Oromia Region. Oromia and Benishangul-Gumuz regions account for the highest production of soybean in the country, 51percent (%) and 40% respectively [16].

Soybean (Glycine max L.) is one of the most important leguminous and oil crop with worldwide growing importance; as food and market commodity. The importance of soybean emanates from the high nutritional value of its grain [9]. Soybean is an alternative protein source to the rural families and can be utilized at home in various forms and the surplus can be sold to other consumers and manufacturers for income [1].

Oilseed crushers produce around 20% of the domestic consumption of edible oil, and 80% is imported mainly as palm oil and soybean oil. The value of imported edible oil is 40 to 50% of the export earnings of oilseeds [17]. Ethiopia's strategic location closer to the world's largest consumers of soybean and soybean products is also a feature which makes it great open door for the nation to target soybean as potential export commodity and import substitution [2]. The proximity of the country to international market and the high market demand for Ethiopian Soybean seed/especially organic soybean seed/can is considered as another opportunity [10].

The current Soybean production in small farmers or large scale is highly dependent on marketable value and suitability of the environmental conditions. The suitability of potential environmental opportunity for Soybean crop production and the presence of the yield potential of Soybean in Ethiopia would give better image and possibility for yield gap improvement [10].

With subsistence agriculture practiced by majority small holder farmers, yield gaps are high and poor soils, amongst other constraints add to the difficulties for sustainable farming and incomes [12]. In order to develop suitable strategy to improve the productivity levels of legumes, it is imperative to assess the potential yield and yield gaps between the potential and actual yields [3].

Thus, the activity was intended to demonstrate improved Gishama soybean variety and practices through large scale- clustered farm approach with objective to increase farmers' awareness towards access and adoption of full package soybean technologies; strengthen agricultural organization, research and extension linkage; improve production and productivity, evaluate profitability as well as exploring production constraints.

II.RESEARCH METHODOLOGY

A. Description of the study area

The activity was conducted in Assosa zone (Bambasi and Assosa) districts. Assosa zone is located in Benishangul-Gumuz region which is approximately 680 km west of Addis Ababa. It consists of seven districts (Assosa, Bambasi, Homosha, Menge, Sherkole, Kurmuk and Oda bildigilu). The total population were estimated to be 385,501[8]. Farmers in the area practice mixed production system. Crop like Maize, Sorghum, Soybean, Teff and Groundnut are mainly produced by farmers. Livestock such as Cattle, Sheep, Goat and poultry are mostly reared by the farmers in the area.

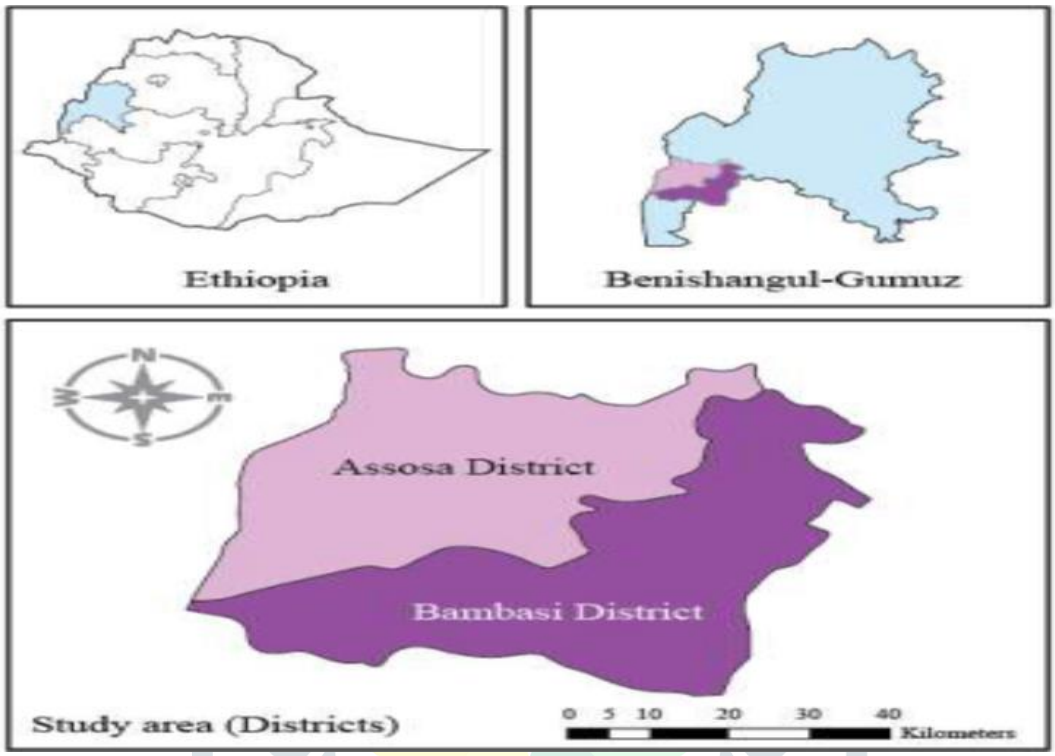

Figure 1. Districts in which demonstration was undertaken

B. Planning meeting

At the initial stage of the activity planning meeting was conducted with multi-disciplinary research team of Assosa agricultural research center to fill the research and extension gap in the area.

C. Site and farmers' selection

Bambasi and Assosa districts were selected purposively based on the potential for soybean production. At second stage, a total of 11 small administrative units in the districts were selected purposively according to the intensity of soybean cultivation within the same agro ecology. The host farmers were selected based on willingness to conduct the activity, accessibility for supervision and having minimum of 0.25 hectare (ha) land to be clustered in collaboration with researchers', development agents and agricultural experts. Women farmers were considered during selection.

D. Input supply

Required amount of gishama soybean variety seed was supplied at a seed rate of 60 kilogram per hectare (kg/ha) and was planted at spacing of 60 centimeter between rows and 5 centimeter between plants. 100 kg/ha NPS fertilizer and 0.5 kg/ha boifertlizer was applied at sowing time.

E. Method of data collection

Measurements as well as different Participatory Rural Appraisal (PRA) approach such as focus group discussion, interview and observation were used to collect parameters and information.

F. Data and Source of data

Volume of seed distributed, number farmers benefited, the number of site addressed, number of field day and training participants, the volume of the commodity harvested, yield data, yield gap, production cost, return gained, farmers preference, production constraint and farmers perception were collected.

G. Method of data analysis

For this study the following method of data analysis are employed and the detail of the methodology is given as follows

1. Yield gap analysis

The analysis of yield gaps is important to identify the potential sources of gains in agricultural yields and to develop solutions to reduce these gaps. These solutions can increase crop yields and optimize the use of applied agricultural inputs [7]. Yield gap analysis and technology index given by [15] was calculated using the following formula,

Technology gap=potential yield-demonstration yield …….... (1)
Extension gap=demonstration yield-farmers practice yield …….. ……..... (2)
Technology index= (potential yield-demonstration yield) / (potential yield) x100…….... (3)

2. Preference ranking

Through focus group discussion soybean producer farmers were asked to list important traits of soybean verities to be selected. Based on the farmers criteria pair wise matrix ranking was conducted to identify the most important traits. Based on the selected traits the variety was ranked through and weigh score was calculated.

3. Cost -benefit analysis

Cost-Benefit Analysis (CBA) is an analytical tool for judging the economic advantages or disadvantages of an investment decision by assessing its costs and benefits in order to assess the welfare change attributable to it [6].The broad purpose of CBA is to help social decision-making and to increase social value or, more technically, to improve allocative efficiency [5]. For the calculation the following formulas was applied to conduct benefit cost ratio.

$$\text{Benefit cost ratio} = \frac{\text{Total retutn(TR)}}{\text{Total cost(TC)}} \quad \ldots\ldots 4$$

Where TR= yield x price per unit, TC= total variable cost +fixed cost.

4. Break-even analysis

Break-even analysis determines the "break-even point", at which operations neither make money nor lose money [13]. Break-even analysis is performed to determine the value of a variable or parameter of a project or alternative that makes two elements equal, for example, the sales volume that will equate revenues and costs [4]. The break-even point, there is no gain or loss; hence costs are equal to revenues. And the following formula was used to employ the calculation.

$$\text{Break} - \text{even sale price} = \frac{\text{Average total cost}}{\text{average totla yield}} \quad \ldots\ldots (5)$$

$$\text{Break} - \text{even yield} = \frac{\text{Average total cost}}{\text{average price}} \quad \ldots\ldots (6)$$

5. Sensitivity analysis

Sensitivity analysis is a technique for investigating the impact of changes in project variables on the base-case (most probable outcome scenario). Typically, only adverse changes are considered in sensitivity analysis. The purpose of sensitivity analysis is: 1, to help identify the key variables which influence the project cost and benefit streams 2, to investigate the consequences of likely adverse changes in these key variables 3, to assess whether project decisions are likely to be affected by such changes 4, to identify actions that could mitigate possible adverse effects on the project [11] and was calculated using spread sheet.

6. Constraint analysis

Major problem was identified in soybean production and Rank Based Quotient (RBQ) of constraints was calculated based on the ranking done by 30 respondents. Rank Based Quotient was calculated using the following formula given by [14].

$$(\text{RBQ}) = \sum \frac{\text{fi}(n+1)-\text{ith}}{N \times n} \text{ x100} \quad \ldots\ldots (7)$$

Where
i- is ith rank
fi- Number of respondents giving the particular point at ith rank
N- Total number of respondents
n- Number of ranked items

III. RESULTS AND DISCUSSION

A .Capacity building

For effective implementation of the demonstration, training was organized for farmers, development agents (DAs) and experts on agronomic practice, crop protection and post-harvest handling of soybean production. The training was provided via lecture and practical aided by audio recording and video capturing through the region mass media to reach the wider community and to alleviate the COVD-19 impact on production and productivity. The training was given by multidisciplinary team of researchers of Assosa Agricultural Research Center. A total of 321 farmers (268 men and 53 women), 27 development agents and 13 agricultural experts were trained in 2020 and 2021 cropping seasons.

Table 1- Trainees on soybean large –scale demonstration (LSD), 2020-2021

Participant	2020		2021		Total
	Men	Women	Men	Women	
Farmers	171	8	97	45	321
Development agents	8	5	8	6	27
Agricultural experts	3	1	8	1	13

Source: LSD hosted participants

B. Beneficiaries

The demonstration was conducted on 11 clusters of 248.5 hectare (ha) land covered in 11 kebeles. From Large-scale demonstration 421 men and 88 women farmers were benefited with a total gain of 497,298.2 kilogram (kg) soybean production as presented in table 2.

Table 2-Demonestration beneficiaries 2020-2021

Item	Assosa			Bambasi			Total
	2020	2021	Sub -total	2020	2021	Sub-Total	
Men recipients	75.0	76.0	151.0	161.0	109.0	270.0	421.0
Women recipients	2.0	40.0	42.0	11.0	35.0	46.0	88.0
Area coverage (ha)	21.0	46.5	67.5	76.5	104.5	181.0	248.5
Cluster number	2.0	3.0	5.0	2.0	4.0	6.0	11.0
Seed disperse (kg)	1260	2790	4050	4590	6270	10860	14910
Production (kg)	38325	91837.5	128250	159196.5	221905.8	380516.3	497298.2

Source: LSD fields

C. Field day, exchange visit and farmers perception

Field days and exchange visits were organized to create awareness and demand on soybean technologies and demonstration approach. 668 farmers, 113 officials, 104 DAs and experts were attended. Total of 110 brochures which explain soybean production and management practices were distributed. The message was conveyed through Benesguangul-Gumuz mass media to size the information for the community. Hosted farmers said ‘’the demonstrated soybean variety helps for revenue generation. Also helps for soil fertility improvement and for vermicomposting. Farmers perceived the importance of the approach, in controlling different insects, pests and diseases; promoting habit of team work, helps to exchange ideas, improving cultural practices, strengthening joint problem solving, improving knowledge, encourage surplus production for market, facilitate input utilization, encourage income for wage laborer in the area, facilitating market access as well as rising the capacity to deal with traders selling at reasonable price and encourage availability of seed. Farmers assumed tractor with planter, thresher, training on soya recipe and proofing reasonable market price could help to sustain the current approach and production improvement.

Table 3-Field days and exchange visits, 2020-2021

Participants	2020		2021			Total
	Men	Women	Men	Women	Youth	
Farmers	50.0	15.0	467.0	85.0	51.0	668.0
Officials	75.0	2.0	31.0	5.0		113
DAs and experts	40.0	10.0	44.0	10.0		104

Source: Author noting from LSD attended

D. Yield performance

As shown in table 4, average yield was 2,001.2 kg/ha for 2020 and 2021 demonstration years. The maximum yield ranges from 2,000 kg/ha (Assosa district) to 2,400 kg/ha (Bambasi district). The maximum yield at each location was obtained due to relative fertile soil to the other demonstration site. The maximum yield across location ranges from 2000 kg/ha and above and mean yield ranges 1900 kg/ha and above indicated potential of the soybean crop production in the area. Farmers average yield (without full package and intensive management practice) was 1,275 kg/ha across the location for 2020 and 2021 years.

Table 4-Yield performance of Gishama soybean variety in kg/ha, 2020-2021

Woreda	Demonstration yield								Farmers yield
	2020			2021			2020-2021	2020-2021	2020-2021
	Max	Min	Mean	Max	Min	Mean	Mean yield	Total mean	Mean yield
Assosa	2000	1650	1825	2250	1700	1975	1900	2001.2	1250
Bambasi	2400	1762	2081	2400	1847	2123.5	2102.3		1300

Source: LSD fields

E. Yield gaps

As indicated in table 5, mean technology gap (yield gap I was found 1,198.8 kg/ha. YG I is considered difficult to bridge because of environmental differences between on-farm and research station situations such as very small plot sizes with optimum homogeneity and the technical expertise available at research stations. Though YG I cannot be bridged completely, it gives an indication of the upper limits of productivity that can be achieved in a given environment [3]. Mean technology index shows high variation and found 37.5% indicates increasing the yield by improving soil fertility with recommended package. The mean extension gap (yield gap II) was calculated and found 726.2 kg/ha. YG II is manageable as it is mainly due to the differences in the management practices and input use [3]. Focus on the application of appropriate extension methods and familiarize the farmers with recommended input utilization and improved technology practices would bridge the extension gap observed.

Table 5-Yield gap analysis of Gishama soybean variety, 2020-2021

District	Potential yield	Demonstration Mean	Farmers Mean	Technology gap (Yield gap I)	Extension gap (yield gap II)	Technology Index (%
Assosa	3200.0	1900.0	1250.0	1300.0	650.0	40.6
Bambasi	3200.0	2102.3	1300.0	1097.7	802.3	34.3
Total mean	3200.0	2001.2	1275.0	1198.8	726.2	37.5

Source: LSD fields

F. Trait and variety preference

Farmers main preferred traits were productivity, tolerance to disease, tolerance to shattering, biomass and high branching. As shown in table 6, farmers' preferred Gishama soybean variety because of better grain yield, tolerance to diseases, tolerance to shattering, biomass for soil fertility restoration and weed suppressing potential due to high branching nature.

Table 6-Soybean Gishama variety on selected traits, Rank 1= poor, 2= medium, 3= good

variety traits	Trait weight	Variety weight across traits
Productivity	0.33	0.66
Tolerance to disease	0.27	0.54
Tolerance to shattering	0.2	0.6
Biomass	0.13	0.39
High branching	0.07	0.21

Source: Farmers ideas from discussion

G. Cost of soybean production

Soybean producer farmers spend total mean of 28,780.96 ETB per hectare (ETB/ha). The higher cost was associated with the variable cost such as materials and labour cost. Materials such as seed, inorganic-fertilizer, boifertlizer and packaging accounted total mean cost 3,930.24 ETB. Labour contains land clearing, ploughing, row planting, hoeing, weeding, harvesting, threshing and transporting accounted total mean cost 22850.72 ETB. This indicates, soybean production incurred 85.32% labour cost compared to materials cost which was 14.68% of variable cost. Land was considered as fixed cost of the input.

Table 7-cost of soybean production (ETB/ha)

Input	Assosa		Bambasi		Total	
Input cost	Mean cost	% cost	Mean cost	% cost	Total mean	Total %
Seed	1590.00	40.66	1590.00	40.25	1590.00	40.46
Inorganic fertilizer	1700.00	43.48	1700.00	43.03	1700.00	43.23
Boifertlizer	240.00	6.14	240.00	6.08	240.00	6.11
Packaging	380.00	9.72	420.46	10.64	400.24	10.18
Sub total	3910.00	14.73	3950.46	13.62	3930.24	14.68
Labour cost						
Land clearing	1500.00	5.65	1500	6.5	1500	6.56
Ploughing	3500.00	13.18	3800	16.48	3650	15.97
Row planting	2000.00	7.53	2000	8.67	2000	8.75
Hoeing	4000.00	15.07	4000	17.35	4000	17.50
Weeding	4000.00	15.07	4000	17.35	4000	17.50
Harvesting	3000.00	11.30	3000	13.01	3000	13.13
Threshing	3500.00	13.18	3500	15.18	3500	13.52
Transporting	1140.00	4.29	1261.38	5.47	1200.72	0.06
Sub total	22640.00	85.27	23061.38	85.38	22850.72	85.32
Variable cost	26,550.00	92.99	27,011.84	93.11	26780.96	93.05
Fixed cost	2,000.00	7.01	2,000.00	6.89	2,000.00	6.95
Total cost	28,550.00	100.0	29,011.84	100	28,780.96	100

Source: Author computation from LSD fields

H. Financial return analysis

As shown in table 8, farmers obtained total mean net profit of 24,250.84 ETB/ha. The benefit cost ratio accounted 1.84 birr implies for every birr incurred the farmer gain benefit of 1.84 birr. This shows soybean production by large-scale cluster farm is a profitable enterprise in the area.

Table 8-Finacial benefit of Gishama soybean production (ETB/ha)

Variable	Assosa	Bambasi	Total mean
Mean yield kg/ha	1900.00	2102.3	2001.2
Fixed cost	2,000.00	2,000.00	2,000.00
Variable cost	26,550.00	27,011.84	26780.96
Total cost	28,550.00	29,011.84	28,780.96
Price	26.5	26.5	26.5
Revenue	50350.00	55710.95	53,031.8
Gross margin	23,800	28699.11	26250.84
Net profit	21,800.00	26,699.11	24,250.84
Net profit margin (%)	43.30	47.9	45.73
Benefit cost ratio	1.764	1.92	1.84

Source: Author computation from LSD fields

I. Break even analysis

To know the point in which total cost equals total revenue the break-even analysis was conducted. A break-even point analysis is used to determine the number of units or price of units needed to cover total cost. The result showed the break-even sales price to cover total cost was 14.38ETB/kg. The break even yield to cover total cost was 1,086.07 kg. This indicate 1,086.07 kg/ha or minimum price of 14.38 ETB/kg is needed to cover the total cost for soybean production in the area.

J. Sensitivity analysis

To determine the effect of yield, price, variable and fixed cost on the profitability of soybean production, sensitivity analysis was conducted. As indicated in table 9, 30% worse in yield and price would result 65.6% decrease in profit. As well as 30% worse variable cost and fixed cost would result 33.13% and 2.47% decrease profit respectively. Thus the profitability of soybean is more sensitive to a fall in yield, price and increase variable cost other variables remain constant.

Table 9-Sensitivity of Gishama soybean production profit (ETB)

Variable	Original value	Original profit	Assumption 30% worse		
			New value	New Profit	Change %
Mean yield kg/ha	2001.2	24,250.84	1400.84	8341.3	65.6
Mean price ETB/kg	26.5		18.55	8341.3	65.6
Mean Variable cost ETB	26780.96		34815.3	16216.5	33.13
Fixed cost ETB	2000.00		2600.00	23650.84	2.47

Source: Author computation from LSD fields

K. Soybean production constraints

Focus group discussion was conducted with men and women farmers whose average age of 45 years of men and 35 years of women having average farm experience of 28 for men and 25 for women, and also men average education of grade 6 while females were illiterate. Preferential ranking method was used to identify soybean production constraints as shown in table 10. Based on the ranks given, rank based quotient was calculated and production constraints were documented. The analysis of the data reveled low soil fertility, lack of reasonable grain price, small plot of land allocation, high fertilizer price, lack of tractor for ploughing followed by lack of thresher were the major constraints to soybean production. Understanding and addressing limitation to production in the region could have positive impact on soybean production and productivity improvement.

Table 10-Rank based soybean production constraints

Constraints	Ranks						RBQ	Rank
	1	**2**	**3**	**4**	**5**	**6**		
Low soil fertility	18	5	4	3	0	0	87.78	1
Lack of reasonable grain price	11	9	7	3	0	0	82.23	2
Small plot of land	7	12	8	3	0	0	79.44	3
High fertilizer price	8	10	6	4	2	0	76.67	4
Lack of tractor	5	7	12	4	2	0	71.67	5
Lack of thresher	4	5	3	7	9	2	56.66	6

Source: Group discussion with LSD participants

IV. Conclusion

Gishama improved soybean variety average yield has been recorded 2001.2 kg/ha with an indication of soybean crop potential maximum yield 2400 kg/ha in the area. Compared to the farmers' average yield (without full package and intensive management practice) the demonstrations fields have 726.2 kg/ha yield advantage. Also Farmers' financial return has been increased. Both men and women farmers preferred Gishama soybean variety because of better grain yield, tolerance to diseases, tolerance to shattering, biomass for soil fertility restoration and weed suppressing potential due to high branching nature. Demonstrations of the technology through large-scale cluster farm approach has been used as learning site and served as seed source for farmers, institutions and NGO involved on agricultural activities in the area. It strengthens the relation between farmers, extension and researchers. Low soil fertility, lack of reasonable grain price, small plot of land allocation, high fertilizer price, lack of tractor for ploughing and lack of thresher was the major constraints to soybean production.

Thus, growing gishama soybean variety, improving production constraints and encouraging large-scale cluster farm approach demonstration is recommended to boost the production and productivity of soybean in the region.

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