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Research Article

On-farm demonstration and evaluation of newly released Soybean (*Glycine max*) varieties with production technology in pre-extension approach at Karat zuria district, Konso zone, Southern Ethiopia

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Abstract

Evaluation and demonstration of soybean technology was conducted at Karat zuria district of Konso zone in Southern Ethiopia in 2022/23 cropping season with the objectives of to analyze socio-economic profitability, farmers' preference and acceptability under farmers' conditions. Therefore, this study aims to demonstrate newly a released soybean variety with production technology. The district was purposively selected based on potentiality for Soybean production. Two kebele's were selected purposively based on potential of the crop.Farmers, development agents and kebele level administrative bodies were trained by the researchers. It was implemented on 20 farmer's field and 2 FTCs at 200m^2 areas of adjacent fields with 40cm*5cm spacing b/n row and plant respectively and 60 kg/ha seed rate and 100 kg/ha NPS. All recommended agronomic practices were applied equally to all fields and the fields were closely supervised and properly managed. The highest (1,858.5 kg/ha) and (1,862.5kg/ ha) grain yield were recorded from Nyala variety at farmers field and FTC respectively. The result showed that there is no that much statistically significant difference at 5% probability level between Nyala and Gazale. The cost benefit analysis results also showed that using Gazale (37,873.75 ETB/ ha) can make farmers' slightly profitable than Nyala (35,455 ETB/ ha). On both locations, even if Nyala performed better yield, farmers preferred Gazale variety in some important attributes, mainly in the attributes of seed size, seed color and marketability. Extension materials like banners, posters, brochures, leaflets were used during the field day to promote the technology. Therefore, Arba Minch Agricultural research centers and seed producer cooperatives should multiply the seeds of Gazale variety the extension system of the Konso zone, Karat zuria district office of Agriculture and similar agro-ecology should expand the soybean.

Keywords: Gazale; Grain yield; Karat zuria; Nyala; Production technology; Soybean; Technology transfer

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1. Introduction

Soybean is one of the most important food plants of the world, and seems to be growing in importance. Globally its oil is the second important cooking oil after palm oil with an mean protein content of 40% and is more protein-rich than anyother vegetables and contains about 20% oil on a dry weight of grain basis of w which 85% are unsaturated and cholesterol free (Voora et al., 2020). The by product is cheap and an important source of protein for both human consumption and animal feed. It can also be used as soy meat and soy milk (Dixit et al., 2011). It 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 (Dugje et al., 2012). It is also an annual crop, fairly easy to grow, that produces more protein and oil per unit of land than almost any other crop. It can substitute for meat and to some extent for milk. It is a crop capable of reducing protein malnutrition (Whigham, 2002).

Soybean was first domesticated in East Asia with Chinese farmers reportedly the first people to grow the crop some five thousand years ago (Boerma & Specht, 2004). From there, it extended into neighboring regions such as the Russian Far East, Korean peninsula, Japan and later widespread to North America, Europe then to South and Central America. Over time, in the mid-19th century, the crop was introduced to Africa from china along the east coast of Africa (Ajama & Kibi, 2022). Soybean is among the major industrial and food crops grown in every continent (Collombet, 2014).

Since, soy bean introduction in Ethiopia in the early 1950s soybean has become one of the most important lowland grain legumes in the country that is highly adapted to diverse agro- ecological conditions including areas of marginal to the production of most of other crops. In Ethiopia, the demand for soybean product is increasing as a result of increasing population growth, agro-processing and urbanization (Bekabil, 2015). Soybean seeds contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free (Thoenes, 2014). The low production and productivity of soyabean in Ethiopia are attributed to many factors. Ethiopia’s strategic places 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 crop and import substitution (Ayalew et al., 2018). The major problems are lack of well adapted and high-yielding cultivars, inappropriate agronomic practices, and lack of marketing and suitable post-harvest management facilities, lack of varieties with stable and high yield potential and lack of good quality seeds are very important limitations to soyabean production by smallholder farmers (Alemu & Embiale, 2023).

Karat district from Konso zone is among the potential production areas of soybean. The area covered and farmers participated in soy bean production increased from time to time but the productivity decreased. But the farmers at the study area are still growing the local varieties with low yield, traditional practice and also farmers have little information about the released and adapted varieties on both agronomic practice and their economic as well as nutritional importance. Low soil fertility, unfavorable grain prices, small land plots, high fertilizer costs, and limited access to machinery (tractors and threshers) were some of the major constraint to soy bean production in the area. To solve this, Arba Minch Agricultural Research Center conducted adaptation of both Gazale and Nyala varieties and obtained (Gazale 1,445 kg/ha, and Nyala1,455 kg/ha) with average national yield of 24.90Q t/ha (CSA, 2021). Therefore, the objective of this study was to popularize the newly released soybean varieties, to assess farmers preference and analyze costs and benefits of the soybean technology in the study areas.

2. Materials and Methods

2.1. Description of the study area

Konso zone is one of the zones of the Southern Ethiopia regional state of Ethiopia. Karat zuria district is one of the districts in Konso zone of Southern Ethiopia. Geographically, it extends from $5^0$30' 00" to $5^0$45' 00" North latitude and 37°10'00" East to 37 °35'00" East longitude. Its altitude ranges from 501 meter to 2,500 meter above sea level. Annual temperature of the area ranges from 15.10 to 27.5℃. The farming system of the district is characterized by mixed crop-livestock farming system dominated by cereals.

2.2. Site and farmers selection

Karat zuria district from Konso zone was selected purposively based on their potentiality for soybean production. Two kebeles and 20 farmers (10 from each kebele) and 2 farmer training centers were selected based on the interest to accept the technology and willingness to provide their land for the demonstration. Farmers research extension group, consists of 14 members was organized also to work with other non- participant farmers in transfer of the technologies.

2.3. Approaches followed

For the demonstration, multidisciplinary approaches were used. Target farmers contributed land preparation and other farm operations, applied all packages according to manuals, participate in visiting and make others to visit his/her field during field days, transfer relevant technology related information to other farmers. Konso zone, Karat zuria district and respective kebele office of agriculture organizations

assigned an expert as a contact person who closely follow up the implementation of the tasks, make monitoring and evaluation at different levels and record all important data during the process, facilitate ways for farmers to get sufficient fertilizers, collect all required data and transfer for responsible bodies, participate in preparation of small meetings and field days. Agricultural Technology Transfer and Communication Researchers from the Arba Minch Agricultural Research Center and researchers from the Directorate of crop were fully involved in all stages from the development of the activities to the results. Extension materials like banners, posters, brochures, leaflets were used during the field day (Figure 1).

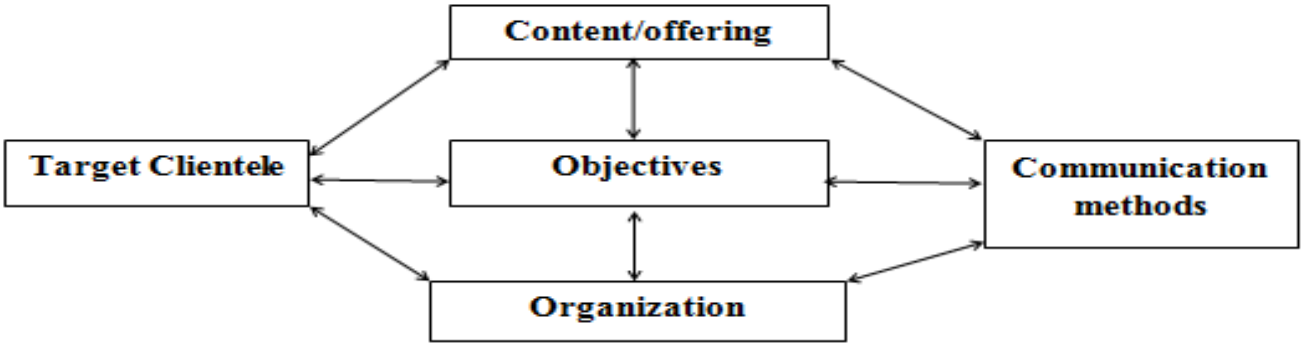

Figure 1. Concept of the technology demonstration (Habremariam, 2014)

2.4. Capacity building training on the technology

One of the extension method used in technology transfer is training.Training and field day can enhance farmer's knowledge and skill (Kebede et al., 2023). About 37 farmers, 6 development agents and 8 administratives were aware of the importance and quality of technologies as compared to the one under production in the training for one day (Table 1). The focus of the training was on

Table 1. Number of participants in training

Kebele	Farmers		Development agents		Others	
	Male	Female	Male	Female	Male	Female
Gocha	14	5	2	1	4	-
Sorobo	16	2	2	1	4	-
Total	30	7	4	2	8	-

Agronomic and management practices from land preparation to postharvest handling through marketing to boost the production of soybean. During training, computer power point presentations translated in local language, leaflets, posters, audiovisuals, etc. were used as training materials and aid.

2.5. Experimental design and technologies used to implement the technology

Two new soybean varieties; Gasole and Nyala were planted side by side on adjacent plots of 200m2 with their production packages (Table 2). The demonstration boundaries were marked by

placing permanent sticks. The demo plots were replicated by participant farmers. NPS was applied during planting and all necessary agronomic practices were applied properly starting from field preparation to harvesting according to FAO (2012) recommendations. Hand weeding was done regularly to ease competition from weeds and the crop solely depended on rainfall (Aleksandras et al., 2009). Harvesting was done by hand and threshing was done by manual.

Table 2. Agronomic recommendations and designs used for both demonstrations of soybean

Practices	Recommendations/ technologies
Number of plots	2 adjacent plots per farmer (Gazale and Nyala) and FTC's
Plot size	10m * 20 m for each varieties on each farmers field and FTC's
Land preparation	ploughed properly (2-3 times)
Planting time	April to 1st week of May
Seed rate (kg/ha)	60
Planting depth(cm)	2 – 5
Spacing(cm)	40 b/n rows and 5 b/n plant
Fertilizer(NPS) rate (kg/ha)	100
Weed Management	Mannual control (2 weeks after planting, again 5-6 weeks), applied uniformly to all plots as required

2.6. Data collection and anal methods

The data was collected through data sheet. The collected data were: planting date,maturity date,yield data, type and number of stakeholders participated by gender in training, field visits, farmer's perception on the different attribute of the technology, costs and income gained.The data on grain yield of the varieties were taken from $200m^2$ from 20 participant farmers by the researchers directly from the field. In addition, perception data were collected using focus group discussion during evaluation periods. The preference towards the technology have been collected from farmers participated on field day by interviewing and discussing with them another day after they have visit the technology. The respondents were responding their preference level on the relative advantage of each characteristic of the introduced varieties.

Mean, minimum, maximum, frequencies, and percentages were used to analyze yield. Farmers‟ preference data were analyzed using simple ranking method in accordance with the given value (De Boef & Thijssen, 2007). Likert scale, which assumes ordinal measure scale from very poor to very good used to analyze farmers preference. Each Likert scale response contains a number used to measure farmer preferences. Moreover, the profitability analysis used to compare the economic benefit of the improved technology was calculated (Eq. 1) by the formula (Drury, 2006).

$$NB = TR - TC \quad (1)$$

Where NB = Net benefit, TR= Total return

2.7. Monitoring and evaluation on the technology

Field day increase technology adoption by 12.2% (Emerick and Dar, 2020). Focus of the field day in this research was on the early generation and seed multiplication of soybean and promotion of its benefits in local farming practices. Finally, in order to evaluate the performance and final outputs of the varieties and share the lessons with different stakeholders', kebele level field days were organized. 156 participants; 119 farmers, 12 Development Agents and 25 other experts and administrates were directly participated in 2 kebeles and appreciated all the things done at farmers field and FTC's (Table 3). They host farmers also gave a brief explanation about what benefit they get from the technology by consuming and selling the product.

Table 3. Number of participants in field visit and field day

Category	Kebele	Farmers		Development agents		Other experts	
		Male	Female	Male	Female	Male	Female
Field evaluation	Gocha	14	5	1	2	11	1
(3 times)	Sorobo	16	5	2	-	8	-
	Total	**30**	**10**	**3**	**2**	**19**	**1**
Field day	Gocha	52	15	4	2	12	-
	Sorobo	40	12	5	1	12	-1
	Total	**92**	**27**	**9**	**3**	**24**	**1**

3. Results and Discussions

3.1. Grain yield performance of newly released soybean varieties at farmer's field

The grand mean (combined data of the two kebele) yield performance of Gazale variety at each site was 1,824.5 kg/ha, and that of Nyala was 1,854.5 kg/ha which indicates that Nyala variety at farmer's field shows better yields than Gazale variety (Table 4).

Table 4. Grain yield performance of farmers' field (N=20)

Kebele	Mean yield performance kg/ha	
	Gazale	Nyala
Gocha	1,828.3	1, 852
Sorobo	1,820.83	1,865
Grand mean	1, 824.5	1,858.5

3.2. Grain yield performance of newly released soybean varieties at FTCs

The demonstration works also implemented in two FTCs of each kebeles for the sake of demonstrating the improved soy bean varieties for non-participant farmers with in and around the kebele. The result showed that the average yield performance of Gazale was 1,837.5 kg/ha and that of Nyala were 1,858.5 kg/ha. Nyala gave better yield both on farmer's field and FTCs (Table 5).

Table 5. Grain yield performance of Farmers Training Centers (n=4)

Kebele	Yield (kg/ha)	
	Gazale	Nyala
Gocha	1,850	1,875
Sorobo	1,825	1,850
Grand mean	1,837.5	1,862.5

3.3. Statistical (t-test) result of the varieties at farmers' field

The grain yield performance of newly released soy bean varieties was greater than the findings of Hawa, Bambasi and Assosa districts of Assosa zone districts (Shita, 2022) as indicated in Table 4. The results of the independent t- test showed that there was a 0.34 Qt/ha yield difference between the Nyala and Gazale varieties (Table 6). Based on the independent t-test ($p = .001 < .05$), the Nyala and the Gazale differ in their yield performance. There was no statistically significant difference between the mean yield of Nyala and the Gazale. Even if there is no significant grain yield between the two improved soybean varieties there is yield variation (+25 kg/ha in Gazale variety) between them. Though the productivity of the soybean obtained in the area is below the national average which is 2270 Kg/ha, but the yield gained in the area is promising result (CSA, 2020). Both improved varieties used for the experiment showed slightly better mean grain yield at FTCs than on farm plots in both kebeles as indicated in Table 6.

Table 6. Mean yield difference t-test analysis of soybean (Qt/ha)

Yield	t	Df	p-value	MD	SED	95% CI	
						Lower	Upper
Equal variance assumed	2.712	19	0.98	0.34	0.237	-0.038	0.065
Equal variance not assumed	2.714	19	0.96	0.34	0.44	0.0367	-0.065

Qt=Quintal per hectare (1Qt=100 kg), Df=Degree of freedom, MD=Mean difference, SED=Standard error difference CI= Confidence interval of the difference

3.4. Cost benefit analysis

The net benefit analysis of the demonstrated variety from one hectare was 37,873.75 ETB and 35,455 ETB of Gazale and Nyala, respectively (Table 7).

Table 7. Cost benefit analysis of the demonstrated varieties

Items	Quantity	Unit price	Soybean varieties	
			Gazale	Nyala
Average yield (kg/hectare)	kg	-	1,837.50	1,862.5
Adjusted yield (-10%)	kg	-	1,753.75	1,25.0
	Birr	ETB 60 (Nyala) and 65 (Gazale)	48,993.75	75.0
Total gain (A)	**-**	**Birr**	**48,993.75**	**46,575**
Seed Cost	kg	50 ETB	3000	3000
Fertilizers costs in kg	NPS	100 kg (22 ETB)	2200	2200
Land preparation cost	Ha	1000	1000	1000
Labor costs per day	Planting	1 day*10 person*60 birr	600	600
	Weeding	2 day*10 person*60 birr	1200	1200
	FA	2 day*6 person*60 birr	720	720
	HT	4 day*10 person*60 birr	2400	2400
Total costs (B)	**-**	**Birr**	**11,120**	**11,120**
Net benefit (C)	**-**	**Birr**	**37,873.75**	**35,455**

NPS= Nitrogen, phosphorus and sulfur, HA=Hectar, FA=Fertilizer application, HT=Harvesting, and transporting

3.5. Farmers preference analysis

Farmers were asked to give a rank from 1-5 on each attribute of the crop where 1= very poor, 2= poor, 3= neutral and 4=good and 5=very good based on farmers criteria's based on 10 criteria's given below. Note: SE=Seed emergency, E=Earliness, RS=Resistance to shattering, RD=Resistance to drought, SS=seed size, SC=seed color, M= marketability,Y=yield, T=Taste, W=weed-suppressing potential. After scoring, each value of the score were added and divided to the number of the criteria's listed by the farmers and finally ranked based on the mean score.Gazale soybean variety preferred than Nyala in some important attributes mainly in the attributes of seed size, seed color and marketability, resistance to shattering, and weed-suppressing potential (Table 8). This shows participating farmers in technology diffusion is very important issue in research.

Table 8. Farmers preferences (n=20)

Varieties	SE	E	RS	RD	SS	SC	M	Y	T	W	Total Score	Mean score	Rank
Gazale	5	5	4	5	5	5	4	4	5	5	47	4.7	1st
Nyala	5	5	4	5	4	4	5	4	4	4	44	4.4	2nd

Gazale | Nyala

Figure 2. Photos taken from demonstration sites at different stages of plant growth

3.6. Awareness Creation on the technology

After the demonstration, all participant farmers were informed of the recommended seeding and fertilizer rates. Surprisingly, 100, 88.98, 66.94 and 56.5% of participant farmers were aware of the spacing, seed rate, fertilizer application and agro-chemical application use respectively after the implementation demonstration in the study area's (Table 9).

Table 9. Farmers aware of the recommended practices of improved soy bean (n=20)

Recommended technology	Number of farmers aware			
	Male	Female	Total	%
Spacing	20	0	20	100.00
Seed rate	14	2	16	88.98
Row planting	14	2	16	88.98
Fertilizer rate	8	0	8	36.45
Fertilizer application	11	1	12	66.94
Agro-chemical application	11	0	11	56.50

3.7. Lessons learned

- Farmers confirmed that, a demonstration of new technology using appropriate extension methods such as training and field days are among the best approaches in technology transfer.
- The use of fertilizer for the common bean especially NPS rate was uncommon in the study areas and this demonstration has tried to demonstrate the yield difference using the recommended NPS fertilizer rate
- Pre-extension technology dissemination and transfer approach played a significant role to easily diffuse knowledge and practice from one cluster to the other and created awareness on disseminated technologies.
- Multi-stakeholders participation and share responsibility in pre-extension demonstration approach reduces the time of adoption of the technology in the community because of the multiple interactions of stakeholders through direct and indirect meetings

- A farmer-Extension-Researcher linkage creates opportunity for jointly participation in problem identification, planning, implementation and finding solution to the farmers

4. Conclusion

Recently released 2 Soybean varieties (Gazale and Nyala) were demonstrated on 20 farmers‟ fields and at 4 FTCs at Karat zuria of Konso zone with the objective of enhancing diffusion and adoption of the variety. Both varieties show better performance in adapting the area especially resisting drought in moisture stressed seasons. Regarding combined grain yield from 2 kebele, 1,824.5 kg/ha and 1,858.5 kg/ha was obtained from Gazale and Nyala from farmers field respectively. Similarly, from FTC's 1,837.5 kg/ha and 1,862.5 kg/ha grain yields obtained from Gazale and Nyala respectively. The cost benefit analysis results also showed that using Gazale (37,873.75 ETB/ha) can make farmers' more profitable than Nyala (35,455 ETB/ha). Even if the average yield of Nyala variety is better, the mean preference score for Gazale was high and farmers in the demonstration site select Gazale variety as their first choice due its some attributes like vigorous seed color, larger seed size and marketability. Its better to disseminate the Gasole variety that has market demand, better market price, and good color. Therefore,the respective Agricultural research center, office of Agriculture of the area should work in collaboration on the Gasole variety in the area and similar agro-ecology by addressing production constraints, participating stake holders and using demonstration approaches.

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Conflict of Interest

The authors declare no conflict of interest

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