

On-Farm Potentials of Common Bean and Its Contribution for Smallholder Farmers' Livelihood and Income

Abstract

To enhance the grain yield and utilization of common bean, many challenges were observed. To tackle the challenges, this experiment evaluated five recently released common bean varieties through farmer's participation. The varieties used for the evaluation were SAB-632, DAB-372, SER-119, SER-125 and KAT-B1. The study showed farmers can harvest a maximum of 2.6 t ha⁻¹ using the improved common bean varieties. This can bridge about 60% of the yield gap observed compared with the farmers' practice. When cultivating the improved varieties farmers can also harvest more than 119,222 birr from one hectare. To compare the value of the benefits and the costs of producing common bean, a benefit-cost ratio (BRC) was calculated and found a 1.57 ratio. Thus, in Sire and similar agro-ecologies that cultivate common beans, it is advised to scale up the SER-119 variety to improve production and profitability.

Keywords: Cost of production, farmers' preference, feasibility, participatory evaluation, sensitivity analysis

Introduction

Common bean is one of the main pulse crops cultivated by smallholder farmers in Ethiopia. Currently it is cultivated on an estimated area of 600,000 hectare (CSA, 2022). According to Tebeka *et al.* (2017), common beans are a significant source of dietary protein, as well as essential micronutrients like iron and zinc. Farmers cultivate common beans for both food and income, and in Ethiopia, it is also an important crop for export (Kidane *et al.*, 2014).

Common bean farmers in Ethiopia harvest low grain yield despite the high potential of research released improved varieties. The improved varieties potential is around 4.0 t ha⁻¹. Whereas common bean farmers harvest not more than 1.7 t ha⁻¹ (CSA, 2022; Fitsum *et al.*, 2021). Studies showed that the grain yield of common bean can be improved when

farmers adopt the improved varieties with recommended agronomic practices. According to Fitsum *et al.* (2021), common bean grain yield were improved by 27% when farmers utilize the recommended technologies.

The national lowland pulse research program with its collaborative institutions achieved a remarkable milestone. The program registered a high grain yield and disease resistant varieties for the last decades (Kidane *et al.*, 2013). Understanding this, an experiment on the participatory evaluation of improved common bean varieties were conducted in Sire district. The objective was to evaluate the best-performing ones and recommend for scaling ups.

Materials and Methods

Site description

We implemented the experiment in the Sire district of Oromia regional state, Ethiopia. In the district, farming is the major economic activity. Cereals and pulses are the major crops cultivated by the farmers. The district is characterized by an altitude range of 1000 to 2500 meters above sea level. The annual rainfall ranges from 800mm to 1200mm. From the district common bean producer kebeles, Biqa kebele was selected randomly. From the kebele, twelve farmer fields were used to lay out the experiment during the 2023 main rainy season.

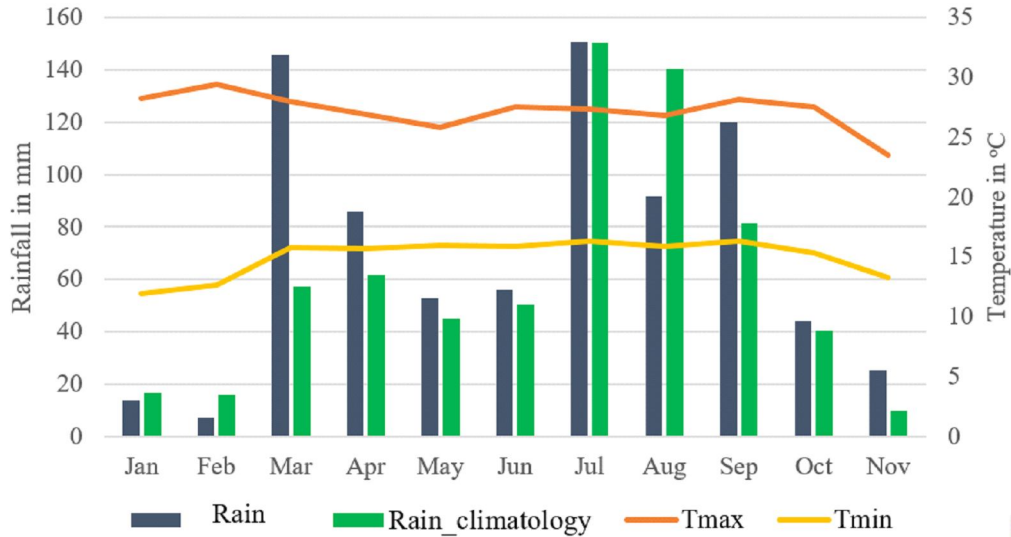


Figure 1. Temperature and rainfall distribution of the study area

Experimental design and managements

In order to replace the low-yielding local varieties grown by farmers, five recently released improved common bean varieties were evaluated using a participatory approach. The varieties used for the evaluation were SER-119 and SER-125 (red seed color), KAT-B1 (yellow color), and SAB-632 and DAB-372 (speckled or sweet bean). Using the target farmers' fields as replications, a randomized complete block design (RCBD) was employed to set up the experiment on farmers' land. The seeds were planted at a rate of 100 kg ha⁻¹, with 40 cm x 10 cm (row x plant) spacing during mid-July, 2023. NPS fertilizer was used at the rate of 100 kg ha⁻¹ during planting.

Figure 2. Research field grain yield performance of common bean varieties (t ha⁻¹)



Picture 1. Demonstrated and evaluated varieties

Data collection

The data collection involved gathering a wide range of agronomic and demographic data, including plant height, flowering and maturity times, seed weight, pod and seed counts, grain yield, as well as demographic details such as age, family size, sex, education level, and farm size. Additionally, feedback from farmers on their trait preferences, input usage, incurred costs, and selling prices were also documented. Pairwise ranking and weight scores methods were used to assess the farmers' preference for the traits identified.

Data analysis

Analysis of variance and descriptive analysis

The researchers utilized ANOVA to evaluate differences among the varieties, calculated a 5% significance level to compare performance, and used pairwise ranking and weight scores to assess farmers' preferences for identified traits. Finally, in order to assess the common bean production feasibility in the study area, benefit-to-cost ratio was calculated.

Results and Discussions

Target farmers characteristics

Farmers targeted to conduct the experiment were 40 years of old on average, and they had larger families (7 members) and more land (3 hectares) compared to the national average (5.1 family members and less than 1 ha). On average, the farmers had 6 years of education. The majority of the farmers selected to host the experiment were male (63%), which was approximately double the number of females.

On-farm performance of common bean

The study showed the common bean varieties differed significantly ($p < 0.001$) in all measured traits. This suggests the evaluated varieties are better performing and they can increase the chance of farmers to select one. The common bean varieties were found to have a significant variation in plant height (43.85 cm to 49.23 cm), days to maturity (82.54 days to 85.46 days), number of pods per plant (13.25 to 16.45), number of branches per plant (6.76 to 9.45) and 2.1 ton to 2.3 t ha⁻¹ for grain yield (Table 1 and 2). The highest plant height (49.23 cm) was recorded by SAB-632 variety. A variety with a short plant height was KAT-B1 with 43.85 cm. Based on the maturity date, the early maturity variety was KAT-B1. It took only on average 82 days for maturity. The highest number of branches per plant and higher grain yield was recorded by SER-119, which is 9.45 and 2.3 t ha⁻¹. The lowest (2.1 t ha⁻¹) grain yield was recorded by KAT-B1, suggesting a positive correlation between short-maturing behavior and a lower yield. The result showed the presence of significant genetic variability among common bean varieties and their traits. These findings are in line with those of Kassahun and Asmamaw (2021) and Gebre-Egziabher *et al.* (2014), who reported significant variations in grain yield and related trait among different varieties of bean. Similarly, Haile *et al.* (2012) documented marked differences in plant height and maturity dates among common bean varieties. However, lower variations were observed in traits such as days to flowering, seeds per pod, and pod length.

Table 1. Common bean varieties and their agronomic traits

Variation	df	PH	DTF	DTM	PPP	SPP	PL	NBPP	GY
Variety	4	56.34*	6.62 ^{ns}	14.73**	25.33*	0.77 ^{ns}	4.72 ^{ns}	15.12**	100664**
Replication	12	27.05	3.74	1.69	19.43	0.53	3.08	2.85	52058
Error	48	22.80	2.55	2.13	6.22	0.48	3.03	2.46	23504

** = Significant $P \leq 0.01$ probability level; PH= Plant height; DTF = Days to flowering; DTM = Days to maturity; PL= Pod length; SPP=Seed per pod; PPP = Pod per plant; N BPP= Number of branches per plant; GY = Grain yield

Table 2. Mean performance of common bean varieties

Varieties	Plant height (cm)	Flowering date	Maturity date	Pod per plant	Seed per pod	Pod length (cm)	No branches per plant	Grain yield (kg)
DAB-372	46.54a	39.92a	85.46a	13.25a	5.38a	11.77a	7.62a	2288.30
KAT-B1	43.85	39.69a	82.54	13.85a	4.81	10.73	6.76a	2119.20

SAB-632	49.23	40.54b	84.62a	14.29	5.37a	12.16	8.16	2325.20
SER-119	47.31a	40.92b	84.23b	16.45b	5.36a	11.87a	9.45a	2338.80
SER-125	48.46	40.77b	84.31b	16.03b	5.25a	11.04a	9.02a	2255.70
Mean	47.08	40.37	84.23	14.77	5.24	11.51	8.20	2265.44
LSD	3.77	1.26	1.15	1.97	0.55	1.37	1.24	120.91
CV	10.14	3.96	1.73	16.89	13.33	15.14	19.13	6.77

Means with the same letters in the same column are not significantly different at a 5% level of significance

Participatory evaluation

The participatory evaluation was conducted during the harvesting time by farmers who cultivate common bean. The farmers were grouped, and a focus discussion was conducted. First, farmers were asked to list the preferred traits of common bean. They identified high grain yield, disease resistance early maturity, less shattering and drought resistance traits as their priority traits. Based on this trait identified, farmers evaluated the demonstrated varieties. It is found that the SER-119 variety is the most preferred one by the common bean farmers. This is due to its high yield, disease-resistant character, less shattering problem and drought-resistance traits. Next to SER-119, farmers selected the SER-125 variety as their second choice. Similar findings were also reported by Fekadu (2013) and Takele *et al.* (2021). According to Walker (2006), voting for the best varieties can be associated with a high likelihood of varietal adoption. Thus, there is a high probability of the SER-119 variety being adopted by the farmers.

Table 3. Preferred traits of common bean by farmers

Preferred traits	SER-119	SER-125	KATB-1	DAB-372	SAB-632
High yield	33	28	21	10	8
Disease resistance	34	27	18	9	12
Early maturity	10	11	37	22	20
Less shattering	31	24	17	12	16
Drought resistance	31	35	15	10	9
Average score	27.8	25	21.6	12.6	13
Rank	1 st	2 nd	3 rd	5 th	4 th

Cost of common bean production

A research report by Walegn (2015) identified various farming activities involved in common bean production. According to the findings of this study, the highest cost incurred was for labor, accounting for approximately 68% of the total cost (see Figure 3).

Figure 3: Cost of common bean production

Farmers earned an average of 41,152.4 birr per hectare from common bean farming. The highest gross margin came from the SER-119 variety. The cost analysis showed a mean total revenue of 119,222 birr/ha with a total variable cost of 78,069 birr/ha. According to Baumol *et al.* (2007), a business is considered profitable and sustainable if its earnings exceed its expenditures. This suggests that growing common beans presents a viable economic opportunity in the study area.

Table 4. Benefit cost ratio

Benefit-cost analysis	SAB-632	DAB-372	SER-119	SER-125	KAT-B1
Grain yield (kg)	2325.2	2288.3	2338.8	2255.7	2119.2
Grain price (birr/kg)	50	50	50	50	50
Grain revenue (birr)	116,259.5	114,416.5	116,941.5	112,786.0	105,957.5
Straw yield (kg)	2500	2350	2300	2400	2350
Straw price (birr/kg)	2.5	2.5	2.5	2.5	2.5
Straw revenue (birr)	6250	5875	5750	6000	5875
Total revenue (birr)	122,509.5	120,291.5	122,691.5	118,786.0	111,832.5
Grain cost production (birr)	78,069.8	78,069.8	78,069.8	78,069.8	78,069.8
Gross margin (birr)	44,439.7	42,221.7	44,621.7	40,716.2	33,762.7
Benefit Cost Ratio (BCR)	1.57	1.54	1.57	1.52	1.43

Sensitivity analysis

The study includes a sensitivity analysis of common bean due to production changes. To check the sensitivity different scenario were taken. Scenario 1 assumes, if the grain yield increases by 20%, as a result the profit margin increased by the same percent, keeping other factors constant. On the contrary, as production cost increases by 20%, the profitability of common bean production decreased by 43.2% compared to the base case scenario. A 10% decrease in the expected yield and a 20% decrease in price may cause a 44.7 % decrease in the profit margin from the base case scenario. Keeping other factors constant, reducing grain yield and prices has a highly negative effect on the profit margin. From the sensitivity analysis, yield and market price are the most influential factors on a farmer's profit.

Table 5: Sensitivity analysis of common bean production (birr/ ha)

Scenario	Gross revenue	Total Cost	Gross Margin	Profit margin (%)
Base case scenario	119222.2	84069.8	41152.4	48.9
Grain yield increase by 20%	141876.6	84069.8	57806.8	68.8
Production cost increase by 20%	83577.7	78789	4788.7	5.7
Price increase by 30%	153203.9	84069.8	69134.2	82.2
Grain yield decrease by 10% & price decrease by 20%	87506	84069.8	3436.2	4.2
Production cost decrease by 20%	119222.2	67255.8	51966.4	77.3

Conclusion and Recommendations

The study found a significant variation among the evaluated common bean varieties in grain yield and yield contributing traits. Based on the result of the experiment, SER-119 was selected for its superiority in grain yield and yield contributing traits. The study showed that farmers could obtain higher returns by cultivating SER-119. The maximum benefit can be achieved when using the SER-119 variety. Among the factors influencing farmers' profit from common bean production, the amount of grain yield harvested and market price are the major ones. The benefit-cost ratio also showed that common bean farming is profitable business in the study area. Thus, in Sire and similar agro-ecologies that cultivate common beans, it is advised to scale up the SER-119 variety to improve production and profitability.

Limitations of the study

The study used cross-sectional research design whereby the experiment was implemented for one year in limited areas. Although the data enables generalization of the findings, it prevented close investigation of several aspects of the relationships in this study.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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