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Research Article

Bridging Yield Gap in Faba Bean Crop Production: Evidence from Large Scale Demonstration at Wolmera and Kolobo District in Central Highland of Ethiopia

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Abstract

Faba bean (Vicia faba L.) is believed to be one of the earliest domesticated legumes next to chickpea. It is an important pulse crop produced all over the world for both foods, feed & it serves as a cheap source of protein The main objective of this activity is to demonstrate improved faba bean technology through a cluster-based crop production approach. Large scale demonstration of faba bean technology is conducted at Wolmera, district and sheger city administration for two years (2021/22-2022/23). Districts, kebeles, and farmers are selected based on potential in faba bean production and farmers' willingness to implement technologies, with woreda agricultural office. 32 farmers and three improved varieties of Wolki, Dosha, and Numan used. 24.85 qts of seed is used to cover 12 hectares of land with a full package. The demonstrate result revealed that the mean, advantage and percent yield increase of the improved technologies across locations shows. The first year (2021/22) yield result showed that variety Wolki at Wolmera in Robgebeya kebele gives a mean grain yield of 28.5 qt/ha which is higher than the national and regional average yield 21.22 and 23.31 qt/ha respectively. In the second year (2022/23) faba bean LSD result showed that the average grain yield harvested across the districts is 27.3 qt/ha greater than the national, regional and zonal average mean grain yield. The maximum grain yield 38.9 qt/ha and an average yield of 32.5 qts/ha was obtained from Robegebeya Kebele. The data indicates that the actual yield from LSD is generally higher than the national and regional average yield in the country. Therefore, the study indicates that maximum faba bean yield can be achieved in fertile soil conditions, controlling diseases like faba bean gall diseases, and applying full crop recommendation packages.

Keywords

Cluster, Faba Bean, Large Scale Demonstration, Technology, Variety

1. Introduction

Faba bean (*Vicia faba* L.) is a globally significant food legume, ranking as the world's most widely produced in its category [1] Ethiopia stands as the second-largest faba bean producer, contributing approximately 18.89% to the global supply, following only China. This highlights the crop's economic and nutritional importance on both a global and national scale. In 2018, the country generated approximately 13.8 million USD from exporting 26,454.8 tons of faba bean [2].

Within Ethiopia, faba bean is a vital staple food, holding a

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prominent position among pulse crops in terms of both area coverage and annual production volume [3]. It's predominantly cultivated in the mid- and high-altitude regions of the country, typically between 1800 and 3000 meters above sea level (masl) [4]. Faba bean accounts for the largest share (31%) of the total area dedicated to pulse production, demonstrating its widespread adoption by Ethiopian farmers. Nationally, faba bean is grown on roughly 520,551.7 hectares of land, engaging an estimated 4,309,978 smallholder farmers. The total production reaches approximately 1.09 million tons, with an average productivity of 2.1 t ha^{-1} [5]. The Central Statistical Agency's (CSA) 2021/2022 report indicates that faba bean occupies 4.27% of the land area allocated to grain crops and contributes 3.33% to Ethiopia's overall grain production [5].

Beyond its role as a food source, faba bean is a multi-purpose legume with considerable environmental and economic benefits for Ethiopia [6]. It serves as a leading protein source, particularly for rural populations who may have limited access to animal protein [7]. Its ability to fix atmospheric nitrogen makes it a valuable rotational crop, improving soil fertility and reducing the need for synthetic fertilizers [8]. Faba bean straw is also an important feed source for livestock in Ethiopia [9].

Despite its significance, faba bean productivity in Ethiopia remains below its potential, with an average yield of 2.1 t ha^{-1}, compared to a potential yield of 5.2 t ha^{-1} [10]. Factors limiting production include climatic conditions, edaphic factors, biotic stresses (diseases, pests, and weeds), and poor agronomic practices [7]. The crop's susceptibility to biotic and abiotic stresses, declining soil fertility and acidity, and the prevalence of old, low-yielding local landraces contribute to these low yields [11]. Limited adoption of certified improved seeds by farmers (only 0.8% of pulse-cropped areas covered by improved seeds in the 2017/18 growing season) further exacerbates the problem [12]. Consequently, faba bean productivity under smallholder farmers averages less than 1.89 t ha^{-1} [13]. Gall disease of faba bean is also a significant biotic stress [14].

To address these challenges and enhance faba bean production, initiatives are underway to demonstrate and promote high-yielding and adaptable varieties (Numan, Wolki, and Dosha) within specific study areas using a cluster-based farming approach These efforts aim to increase faba bean yields, improve farmers' livelihoods, and ensure a sustainable supply of this valuable crop, ultimately contributing to nutritional security, economic stability, and the well-being of rural communities.

2. Materials and Methods

2.1. Description of the Study Areas

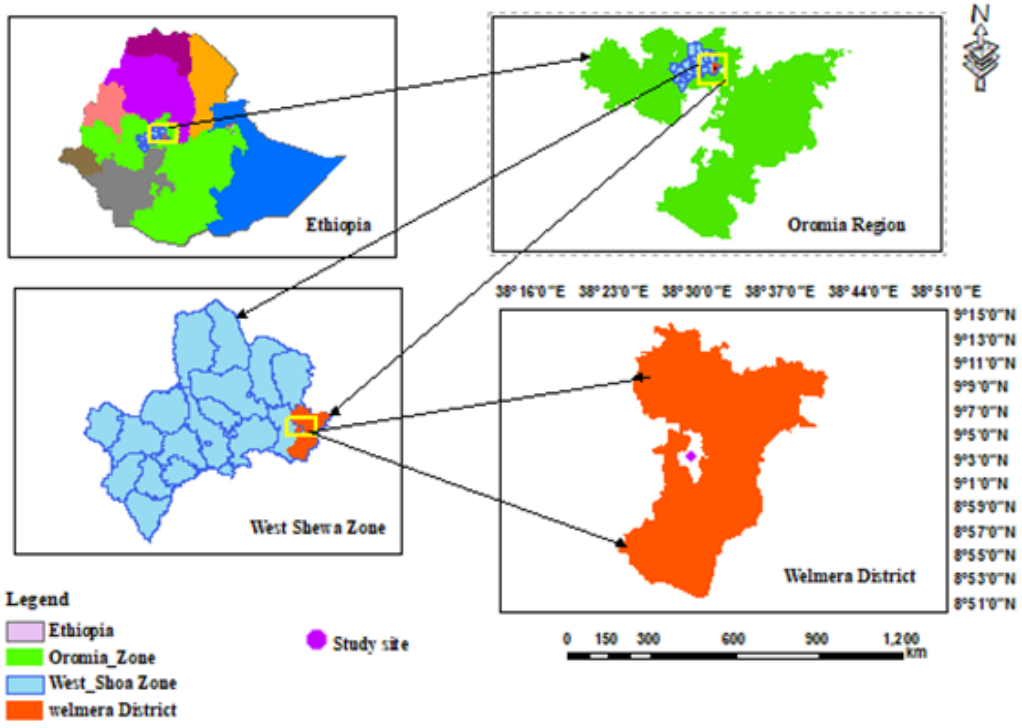

Figure 1. *Map of Study Area.*

Wolmera district one of west Shewa zone Oromia region, Ethiopia, which is located at distance of 30 km west of the capital, Addis Ababa at latitude 9 °3' N and 38 °30' E longitude. The total surface area of Wolmera district is about 66,299 hectares and the altitude of the district is ranging from about 2,000-3,380 m.a.sl. Climatically, most parts of the district are dega (61%) and woina - dega (39%) of agro climatic zones. The mean monthly temperature (T °) and total annual rainfall are 16.5 ℃ and 1,067 mm respectively. The district constitutes 23 rural and 3 urban Kebles. The total population of the district was estimated to be 119,031; of which 59,847 were males and 59,184 were females. The total population in terms of household head was estimated to be 12,343; of which 10,460 were male household heads and 1,883 were female household heads [15].

The study area, Kolobo is located in the sheger city, Oromia Regional State of Ethiopia, between 9 °1' to 9 °2'N and 38 °34' to 38 °35' E. It is 20 km west of Addis Ababa, neighboring to the west Holeta and Gefersa to the east. The area has an altitudinal range from 2,200-2,910 m.a.s. The mean monthly maximum and minimum temperature in the study area are 23.5 ℃ and 8.6 ℃, respectively. The hottest month is March with maximum temperature of 26.13 ℃, followed by May 25.19 ℃ and the coldest month is December with a temperature record of 8.5 ℃.

2.2. Sample Size and Sampling Techniques

Large scale demonstration of faba bean technology was conducted at Wolmera, and Kolobo districts for two years. The target districts, kebeles and host farmers were selected purposively based on their potential in faba bean production and farmer's willingness to implement the technologies to allot a minimum of 0.25 hectares of land for the intended purpose. Site and farmer selection was done by the participation of woreda agricultural experts and Kebele DAs.

2.3. Methods of Data Collection and Analysis

Both qualitative and quantitative data were collected through supervision and follow up of the activity. A data record sheet was prepared to collect the data. Thus, field observation, contacting the target farmers, group evaluation and focus group discussion during the field visit were the data collection methods. Yield data and farmers' preference towards the variety were collected from the farmer's field. The number of farmers participated in training and field day, the number of locations addressed, the amount of seed distributed and the number of farmers benefited from the demonstration process were major types of data collected during the activity. Finally, the collected quantitative data were analyzed using descriptive statistics (mean, yield advantage and% yield increase) and Qualitative data (yield gap) were analyzed using narrations.

3. Results and Discussion

3.1. Location and Farmer Selection

The target districts, kebeles, and host farmers were selected purposively based on their potential in faba bean production and farmers who are willing to organize themselves in cluster farms. The site and farmers selection were done in collaboration with woreda agricultural experts and Kebele DAs. Faba bean growing potential kebeles were selected from the participant districts for the study. Accordingly; the plot area of smallholder farmers in the cluster, the recommended rate of seed (200 kg ha^{-1}) of improved tef (Wolki, Desha, Numan) varieties were distributed for host farmers.

The seed was delivered free of charge on a revolving basis. Farmers who received the seed were reached into an agreement to use and return an equal seed amount for the next generation seed right after harvesting to be used by other farmers in the following cropping season. Besides, access to fertilizer was facilitated for host farmers by extension offices at the district and kebele level. The chemical fertilizer was used based on the district level recommendation. In this activity, a total of 32 farmers were involved out of which 21 were male and 11 were female farmers. The total amount of seed distributed and the area covered by this technology were 24.85 qt and 12.5 hectares of land respectively (see Table 3).

Table 1. *Faba bean technology distributed and farmers benefited, 2021/22 cropping season.*

Cropping Season	Zone	District	Kebele	Varieties	Amount of seed dis. (qt)	Area Covered (ha)	Direct Beneficiary		
							Male	Femele	Total
2021/2022	West Shewa	Welmera	Robgebeya	Wolki	1.35	0.75	1	0	1
			Dufa	Dosha	4.5	2.25	3	2	5
	Sheger city	kolobo	Wechecha	Wolki	2.5	1.25	4	0	4
Total	2	2	3	2	8.35	4.25	8	2	10

Table 2. Faba bean technology distributed and farmers benefited, 2022/23 cropping season.

Cropping Season	Zone	District	Kebele	Varieties	Amount of seed dis. (qt)	Erea covered (ha)	Direct Beneficiary		
							Male	Femele	Total
2022/2023	Sheger city	Kolobo	Wechecha	Numan	8.5	4.25	9	2	11
	West Shewa	Welmera	Dufa	Numan	6	3	0	7	7
			Robgebeya	Numan	2	1	4	0	4
Total	2	2	3	1	16.5	8.25	13	9	22

Table 3. Summary of Faba bean Technology Transferred through Large Scale Demonstration from 21/22- 2022/23 cropping season.

Cropping Season	No of zone	No of district	No of Kebele	No of varieties	Amount of seed dis. (qt)	Area Covered (ha)	Direct Beneficiary Farmers		
							Male	Femele	Total
2021/2022	1	1	3	3	8.35	4.25	8	2	10
2022/2023	1	1	3	3	16.5	8.25	13	9	22
Total	2	2	3	3	24.85	12.25	21	11	32

3.2. Training, Field Visit, and Field Days

Before implementing the activities farmers, agricultural experts, development agents, and administrators were trained on improved faba bean production and management practices, clustering approaches, acid soil management, post-harvest handling, and market linkage. The training was conducted at Wolmera, Wereda and Sheger city administration. In these training program farmers, agricultural experts and administrators, and Kebele DAs participated.

Finally, field days were organized at different stages of the crop to collect feedbacks and share experience with a team of researchers from extension, faba bean breeding, protection, technology multiplication and seed research, farmers, DAs and agricultural experts actively participated in evaluating the performance of the technologies at the field level.

As a result, feedbacks from farmers and agricultural experts on varietal performance were collected during field evaluation and field days. Among local seed and the demonstrated varieties on a large scale, varieties Wolki, Dosha and Numan were preferred by farmers because of their better yield performance. In addition, the participant farmers appreciated the ability to control the faba bean gall disease with Noble 25 fungicides.

Figure 2. Faba bean cluster at the study area.

3.3. Yield Performance of Demonstrated Fabe Bean Varieties Using LSD Approach

The mean grain yield, yield advantage and percent yield increase of the improved technologies across locations are illustrated below in Table 4 The first -year yield result showed that variety Wolki at Wolmera in Robgebeya kebele gave a mean grain yield of 28.5 qt/ha which is higher than the national as well as the regional average yield of 21.22 and 23.31 qt/ha respectively. The lower yield was recorded in Dufa kebele by Dosha variety as compared to the national as well as the regional average yield because of faba bean gall diseases and hail damage occurred during flowering stage (see Table 4).

Table 4. *Mean grain yield qt/ha, Yield advantage (qt) and percent yield increase of faba bean varieties demonstrated in LSD across two districts, 2021/22 cropping season.*

District	Kebele	Varieties	Average Grain Yield qt/ha			Yield Advantage		% Yield Increase	
			Demonstrated	Regional	National	Regional	National	Regional	National
Welmera	Robegebeya	Wolki	28.5	23.31	21.22	5.19	7.28	18.21	25.54
	Dufa	Dosha	21.3	23.31	21.22	-2.01	0.08	-9.43	0.37
Kolobo	Wechecha	Wolki	24.5	23.31	21.22	1.19	3.28	4.86	13.39
Mean			24.76	23.31	21.22	1.45	3.45	4.54	13.1

The second year faba bean LSD result showed that the average grain yield harvested across the two districts was 27.33 qt/ha greater than the national, and regional mean yield reported in the season. The maximum grain yield 32.5 qt/ha was obtained from Robegebeya kebele and the demonstrated varieties overall mean grain yield is higher than the national and regional mean grain yield (see Table 5). Generally during the implantation of the activity hail damage and faba bean gall disease were the two most important yield limiting factors for faba bean production. Recently, faba bean gall disease was controlled by treating/ dressing the seed before planting with Noble 25 fungicides at a rate of 150-gram dust for 100 kg of seed.

Table 5. *Mean Grain yield qt/ha., Yield advantage (qt) and percent yield increase of faba bean varieties in LSD across two districts, 2022/23 season.*

District	Kebele	Varieties	Average Grain Yield qt/ha			Yield Advantage		% Yield Increase	
			Demonstrated	Regional	National	Regional	National	Regional	National
Kolobo	Wechecha	Numan	24.5	22.82	20.97	1.68	3.53	6.86	14.41
Welmera	R. Gebeya	Numan	32.5	22.82	20.97	9.68	11.53	29.78	35.48
	Dufa	Numa	25.5	22.82	20.97	2.18	4.53	8.54	17.76
Mean			27.33	22.82	20.97	4.51	6.53	15.06	22.55

4. Conclusion and Recommendation

Faba bean is one of the earliest domesticated legumes next to chickpea. It is an important pulse crop produced all over the world for both foods, feed & it serves as a cheap source of protein. Large scale demonstration of faba bean technology was conducted for two years from 2021/22- 2022/23 cropping season. The finding of the grain yield data result showed that the actual yield obtained from LSD was relatively higher than the national as well as the regional average yield recorded in the country. The result also revealed that, maximum yield of faba bean can be produced under fertile soil condition and controlling diseases like faba bean gall diseases and applying full recommendation packages of the crop. Consequently, it is advisable for farmers and development professionals to employ the LSD technique as a useful extension strategy to help achieve the maximum yield where faba bean potential areas

exist, as it can actually increase output. Therefor agriculture and rural development offices should promote and scale-out the improved faba bean variety with its recommended packages to the study area and similar agro ecology.

Abbreviations

CSA	Sentral Statistic Agency
FAOSTA	Food and Agriculture Organization Corporate Statistical Database
LSD	Large Scale Demonstration

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Author Contributions

Endale Mekonnen: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Supervision, Writing – original draft

Hana Amare: Data curation, Supervision, Writing – original draft

Mamaru Tesfaye: Conceptualization, Data curation, Supervision, Writing – original draft

Conflicts of Interest

The authors declare no conflicts of interest.

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