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On-Farm Demonstration and Evaluation of Improved Faba Bean (Vicia Faba L.) Varieties in North Shewa Zone of Oromia Region, Ethiopia

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Abstract: The demonstrations of faba bean varieties were done in two consecutive years (2016/17 and 2017/18) with production packages in the Degem and Debre Libanos districts in the North Shewa zone of the Oromia region. The purpose of this study is to demonstrate and evaluate the performance of improved varieties under farmers' field conditions in the study areas. The demonstration was done in 18 farmers' fields using four improved varieties Tumsa and Gora for nitosol and Hachalu and Didia for vertisol with local varieties. Descriptive statistics were used to analyze and present the collected data. Grain yield, farmers' performance scores, and feedback were taken from the demonstration sites. In the districts, the demonstration plot size followed was 100 m^2 and a seeding rate of 250 kg ha^{-1}. At planting, DAP fertilizer 100 kg ha^{-1} and biofertilizer 500 g ha^{-1} were applied. The result of the analysis showed that the improved varieties gave a higher yield than the local control variety. The average grain yield harvested in the Degem area showed that an improved variety of Gora and Tumsa improved variety offers 16.7 qt/ha and 15.7 qt/ha, respectively which is higher than the local variety that gave an average yield of 9.2 qt/ha. In the Debre Libanos district, the variety Hachalu and Didia also gave a mean yield of 22.4 and 23.3 qt/ha higher than the local 8.7 qt/ha. The yield advantage of the two improved varieties over local varieties was 1.67 and 1.57 qt/ha and 8.41 qt/ha for Nitosols and 13.7 and 14.6 qt/ha for Vertisols. The performance score result shows that variety Gora ranked first in terms of grain production, disease resistance, marketability, and seed size followed by Tumsa on nitosols and Hachalu followed by Didia on vertisols. Therefore, both the government and non-governmental organizations must support the research and dissemination of geographically adaptable varieties to smallholder farmers.

Keywords: Demonstration, Evaluation, Faba Bean, Variety, Nitosol, Vertisol, North Shewa

1. Introduction

Faba bean is an important legume crop in Ethiopia in terms of both area and annual production. Although Ethiopia has a huge potential to grow and export faba beans, the achievements so far are very low due to the least allocation of land, input sharing, and cultivation and storage practices to these crops, resulting in low production and productivity [1]. While Ethiopia has a huge potential for growing and exporting this crop, achievements to date are very low due to the least share of land, input allotment, and crop management and protection practices provided to these crops resulting in low production and productivity [1]. According to the study of CSA [2], of the total 1,676,888.30 ha of land cultivated for pulses about 520,551.70 ha (4.27%) of the area was allocated to faba beans providing nearly 10.92 (3.33%) million quintals of production in the country. The crop is grown in several regions with an annual rainfall of 700 up to 1000 mm and with altitudes of 1800 to 3000 m asl. The major producers of faba bean in Ethiopia are Oromia, Amhara, SNNPR, and Tigray in that order, mainly produced by subsistence farmers under rain-fed conditions almost always on marginal lands with minimum care and inputs as compared to cereal crops [2].

Faba bean is an important crop in the country as a major food item in the national feeding culture and it is also a major source of income for many farmers in many parts of the country. It has been used in food and markets as a valuable and cheap protein compared to animal products. Faba beans play an important role in restoring soil fertility through appropriate crop rotations that fix atmospheric nitrogen, thereby resulting in savings for smallholder farmers by reducing fertilizers [3]. Faba bean is a means of cash income for the farmers and generates a significant amount of foreign currency for the country. Despite the importance of the faba bean as a source of protein, energy, minerals, and cash income, efforts so far to develop and disseminate better production techniques have resulted in yields below their potential. The national average faba bean yield in Ethiopia under farmers' production conditions is around 2.1 t ha^{-1} [2]. On the other hand, the potential of the crop under improved management conditions is more than 4 t ha^{-1} [4], indicating a yield gap of about 1.9 t ha^{-1}.

The low productivity of faba beans is caused by several limiting factors [5, 6]. At the farm level, productivity appears to be severely limited by three main factors: i) limited or no use of chemical fertilizers for legumes (e.g., phosphates); ii) very limited availability of improved seeds (most pulses are grown from unimproved cultivars with low genetic potential); and iii) the use of traditional agricultural practices (e.g., sub-optimal crop rotation, poor land preparation); iv) diseases and insect pests. However, the yield gap of 1.9 t ha^{-1} for faba bean suggests that there is a potential for increasing production and productivity of smallholder faba bean farmers. The two-way communication between researchers and farmers is a vital component of the high-yielder and disease and pest-resistant varietal development process [7]. Therefore, participatory introduction, evaluation, validation, and dissemination of improved bean varieties with farmers and other stakeholders is of utmost importance to promote sustainable production and productivity. Demonstration of new varieties with production packages is important to make an impact and enable farmers to use the varieties for market-oriented production. The market production system is a way to increase the income of smallholders' needs attention in many developing countries, including Ethiopia. [8]. Recently released improved varieties have good performance and adaptability. However, the introduction of these varieties with production packages has not been widely done to popularize the variety in the study areas. Therefore, this study was conducted to familiarize farmers with improved Faba bean varieties and their production package and to evaluate the performance of the varieties on the farm for further promotion and improvement.

2. Research Methodology

2.1. Description of the Study Areas

This study is conducted on two of the districts Degem and Debre Libanos in the North Shewa Zone of Oromia region, Ethiopia. The first location was the Degem district located 125 km distance to the north direction of Addis Ababa, the capital city of the country. There are 18 peasant administrations (PA), one village town (Ali doro), and the district capital, Hambisso, in the study area. According to [9], the total population of the district is estimated at 123,319, of which 60,427 are men and 62,892 are women; of its population, 5,464 or 4.4% are urban residents, while 117,855 or 95.6% live in rural areas. Degem has an estimated area of 674.85 square kilometers and an estimated population density of 174.2 people per square kilometer. The main crops grown in the region were barley, beans, wheat, teff, and oats. Faba beans are grown in the region for domestic use and marketing [9].

Debere Lebanose is the second district of the study area. It is out of the thirteen districts of the zone and far 89 km from Addis Ababa and 22 km from the capital of North Shewa Zone. The total area of the district is 29,776 hectares, of which 23,960 hectares are agricultural land, 2,547 ha is pasture land, 833 ha is forest land and 160 ha is other. The district has ten rural Kebeles and one administrative town. Agro-ecologically the district is divided into three parts i.e. Dega which covers 60% of the area, Weyna Dega 30%, and Kolla 10% respectively. The district receives annual rainfall that ranges from 800-1200 mm with a mean of 1090 mm. The dominant soil type in Debre Libanos is black soil which is covered 60% followed by red soils 20%, brown soils 5%, and 15% others. The major crops grown in the district were faba bean, teff, wheat, grass pea, and chickpea. Faba bean is grown in the district for home consumption and marketing [9].

2.2. Data Types, and Methods of Data Collection

This study used primary and secondary data sources. Primary data were collected from participating households focusing on performance parameters of four improved Faba bean varieties (Hachalu, and Didia for vertisol and Gora, and Tumsa for nitosol) with a local check by using the farmer's field as a replication. The data were collected by using structured questionnaires from targeted farmers who cultivate the disseminated cultivars.

2.3. Sampling Procedure and Sample Size

A purposive sampling procedure was followed in this study to select a sample of households. Two areas of the North Shewa zone of Oromia are targeted for demonstration farming activities due to their potential for large-scale production and high demand in the area. The two districts were Degem and Debre Libanos. From these three kebele administrations, each area was selected as a cultivar demonstration based on crop availability and potential. Then, the participating farmers were selected, focusing on owners of suitable and sufficient land for the demonstration activity, who are willing to provide land and labor and proximity to the road so that many farmers can visit the field. An initiative to carry out this activity according to the

recommended packages, good agricultural practice, and willingness to share technology with others. Hence, 18 representative farmers' fields were selected from six Kebeles administrations to introduce Faba bean technologies.

2.4. Methods of Data Analysis

The study employed descriptive statistical analysis to discuss the results of the data collected from smallholder farmers. The descriptive statistical tools mean and percentage were used to show the yield and performance scores of the varieties in different parameters. The yield advantage improved Faba bean varieties over the local varieties was estimated using the formula:

$$f = \frac{Yield\ advantage\ of\ new\ variety - Yield\ advantage\ of\ st.check}{Yield\ advantage\ of\ standard\ chekc\ variety} * 100$$

3. Results and Discussions

3.1. Training Provided on Improved Faba Bean Production

Theoretical and practical training is crucial to improve the awareness, skills, and attitudes of farmers, researchers, and agricultural experts on bean production, agronomic practices, and marketing**.** Special emphasis was given to faba bean gall disease and its controlling methods which is a serious faba bean disease in the areas. Hence, in the training provided smallholder farmers, development agents (DA), and agricultural office experts participated. In addition to the training provided at the room practical training was delivered at the field for a total of 123 stakeholders (105 farmers, 12 DAs, 6 district agricultural experts, and administrators).

3.2. Faba Bean Production Technologies Disseminated and Used in the Study Areas

The technologies were promoted for adoption and monitoring by farmers through various extension techniques such as training, field visits and observations, experience sharing, and field days. The varieties were planted in the third week of June in Degemi and in the first week of July in Debre Libanos. A typical plot is 100 m2 and the sowing rate is 250 kg ha^{-1}. DAP fertilizer 100 kg ha^{-1} and bio-fertilizer 500 g ha^{-1} were given at the time of planting with fully recommended packages. The row planting method was used and the distance between rows and plants was 40 cm and 10 cm [10]. The experiment was weeded twice after 30 days of planting and another six weeks after planting the cultivars. Farm operations such as soil preparation plowing 2-3 times with an ox plow; planting, primary and secondary weeding, harvesting, and threshing were done by the host farmers. HARC supplied the recommended amount of seed and fertilizer. To control the Faba bean gall disease in the Degem district the fungicide called Mancozeb and Redomil gold was applied.

3.3. Field Days Organized and Farmer's Feedback

To demonstrate the varieties with a product package and collect comments from farmers and other interest groups, a field day was organized in the Degem and Debre Libanos region, during which the general successes, challenges, and performance of the presented technologies were evaluated. During this event, the Degem district was attended by guests from the Zonal Agricultural Office, District-level Agricultural Experts, Development Agents, Farmers, and Researchers. About 175 people (100 farmers, 30 development agents, 20 zone and district agricultural experts, and 25 scientists) participated in the event, 25% of the participants were women and the rest were men. A total of 90 (75 men and 15 women) were participated. Agricultural participants participated in the day in the field of Debre Libanos region, including development workers, agricultural specialists, and researchers. Accordingly, farmers' feedback at the field day and focus group discussion on the production of faba bean varieties points raised are it is better to expand the improved faba bean technologies to surrounding farmers, Linkage between stakeholders has to be strengthened, it is observed that the improved varieties with their production package have high yield potential over the local variety in faba bean gall disease resistance, better seed size, highly preferred by the market. Both improved varieties are a little bit late in maturity as compared to the local variety and providing early maturing varieties is better.

3.4. The Yield Performance of Improved Faba Bean Varieties

The average grain yield advantage and yield increase of the improved technologies at different locations in the local Degem region are described (Table 1). The average grain yield of Degem revealed that Gora and Tumsa improved technologies have 1.67 t ha^{-1}, and 1.57 t ha^{-1}, which were significantly higher than the local variety with an average grain yield of 0.92 t ha^{-1}. Although the average performance of the two improved varieties was not significantly different, they were 71-83% better than the local one, indicating the superiority of the improved technology over the local one. This result is consistent with the findings [11] that the Gora and Didia varieties were chosen for high grain yield over locations. Even the potential of the crop under improved management conditions is more than 4 t ha^{-1} [4], indicating a yield gap of about 1.92 t ha^{-1}. The reason for this is due to the both biotic and abiotic production constraints faced.

Table 1. *Yield advantage over the local varieties at Degem and Debre Libanos district.*

District	Variety	Grain yield t ha^{-1}		
		Mean	**Yield advantage**	**% increase**
Degem	Gora	1.67	0.75	82
	Tumsa	1.57	0.65	71
	Local	0.92		
Debre Libanos	Hachalu	2.24	13.7	157.47
	Didia	2.33	14.6	167.82
	Local	0.87		

Source: Own computation result

At Debre Libanos district, the average grain yield of the two improved varieties (Hachalu and Dide'a) was 2.24 and 2.33 t ha^{-1}, respectively, which was higher than that local variety (0.87 t ha^{-1}). The yield advantage and percentage yield increase of the introduced cultivars compared to the local ones were 7.5 and 6.5 qt/ha and 71 and 83% for Nitsols and 13.7 and 14.6 qt/ha and 157 and 168% for Vertisols (Table 1). The yield potential of this location is higher than the national average production, which is 2.1 t ha^{-1} [2]. The potential of faba bean under improved management conditions is more than 4 t ha^{-1} [4], which means a yield difference of approximately 1.92 t ha^{-1}. divided the yield gap into two types: the gap between the research station (potential) and the demonstrated varieties and the gap between the demonstrated crop and the farmers' actual yield performance (real) [12]. The production of the varieties was affected by water logging problems as a result of heavy rainfall distribution during the cropping season. For example, two demonstration plots were lost. Relatively, Hachalu had better plant stands as compared to Didia and the locals. The result is consistent with the findings [13] that indicate the Hachalu variety ranked first in terms of grain yield, disease resistance, and seed color. In the production season, there was also high frost damage at grain grain-filling stage of the crop in north Shewa which resulted in poor crop harvest.

3.5. Performance Sore results Faba Bean Varieties

To measure the preference of farmers the criteria stated and used for ranking were branching ability, disease resistance, pod setting, early maturity, marketability, seed size, and 1000 seed weight. Previously [14] used the number of pods per plant, pod length and plant height, and the grain yield as farmers' evaluation criteria. The results of pre-harvest and post-harvest scores of the improved and local Faba bean verities at Degem district showed that variety Gora was selected by farmers first followed by Tumsa in overall plant performance. This result is supported by the findings [15] that indicated the improved varieties with high yield; large seed size, disease resistance, and resistance to lodging were preferred by farmers and the need to distribute these seeds to the farmers. In at Debre Libanos district, the overall score results of smallholder farmers showed that the variety Hachalu takes the first rank followed by Didia (Table 2). The methods followed to measure the rate of scoring given for the parameters were (1=very good; 2= good; 3= medium; 4= poor and 5= very poor). In this scale, the varieties with the lowest score value which is very good characteristics rank first then the variety having a high score value.

Table 2. *Overall performance scores of faba bean variety at Degem and Debre Libanos district.*

Parameters	District					
	Degem			Debre Libanos		
	Faba bean varieties					
	Gora	Tumsa	Local	Hachalu	Didia	Local
Branching ability	32	36	52	12	32	28
Disease resistance	7	7	15	6	6	9
Pod setting	20	12	28	6	18	12
Early Maturity	45	50	35	45	30	15
Marketability	10	14	30	6	6	18
Seed size	15	30	42	6	6	27
1000 seed weight	20	36	60	12	12	36
Total scores	149	185	262	93	110	145
Rank	1	2	3	1	2	3

Source: Own computation result

3.6. Major Challenges Faced the Faba Bean Production

The Faba bean gall is the new disease that heavily affects the production of faba beans in the area. Except for chemical control, there is no resistant variety developed yet, though the improved varieties have some level of tolerance due to their vigor. This indicates the need for efforts to develop resistant varieties. The water logging problem is serious, especially on black Vertisol. Planting faba bean on Vertisol should properly integrate resistant/tolerant varieties, and a drainage system (BBM or Shurube). The frost problem is a sporadic phenomenon that affects the production of faba beans in some areas. These days it is becoming more devastating and discouraging farmers from growing faba beans. There is no resistant/tolerant variety or management option to minimize its effect. This revealed the need for efforts to develop tolerant varieties. As explained by the previous studies, the most important biotic constraints affecting the production of pulse in Ethiopia are the downy mildew, rust, and wilting root rot complex. Water logging, drought, poor crop management, and lack of improved production technology also limit bean productivity.

4. Conclusions and Recommendations

Ethiopia has a favorable environment and opportunities for growing and exporting Faba bean and the introduction of the improved varieties is critical to improving crop yields and productivity. In this study, practical training was provided to a total of 123 stakeholders. The varieties demonstrated in the study areas were planted in the third week of June in Degem and the first week of July in Debre Libanos. According to agro technical practices, the sowing rate is 250 kg ha^{-1}; 100

kg ha^{-1} amount of DAP fertilizer at; during cultivation bio fertilizer 500 g ha^{-1} and spacing of 40 cm and 10 cm were used. In the field days, a total of 175 individuals participated in Degem and 90 participants attended Debre Libanos district including farmers, DAs, agricultural experts, and researchers.

In the demonstration sites, the Faba bean varieties with their production package gave better yields and the percent yield increase over the farmer's local variety is encouraging. The mean yield harvested at Degem is 1.67 t ha^{-1} of Gora and 1.57 t ha^{-1} of Tumsa varieties which is significantly higher than the local variety which yields 0.92 t ha^{-1}. At Debre Libanos district, the average grain yield of Hachalu and Dide'a was 2.24 and 2.33 t ha^{-1}, respectively, which was higher than that local variety (0.87t ha^{-1}). Among the demonstrated varieties, the farmers relatively preferred Gora first followed by Tumsa for nitosols and Hachalu for vertisols areas. The Faba bean traits preferred by farmers are marketability, maturity date, resistance to disease, branching, seed size, and pod setting. Based on the similar investment per unit area in faba bean production, Gora and Hachalu varieties are more profitable for smallholder farmers due to their higher productivity. Therefore, the study recommends the engagement of stakeholders for the success of variety generation and scaling-up of improved varieties selected by farmers in Faba bean growing areas.

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Conflicts of Interest

The authors declare no conflict of interest.

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