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Participatory on Farm Evaluations and Selection of Improved Faba Bean (Vicia Faba L.) Varieties in Different Districts of Southern Ethiopia

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Abstract
Participatory variety evaluation and selection trials involving farmers in Southern Ethiopia were conducted on farm in the districts of Duna, Doyogena, Angacha and Sodo zuria in Meher season of 2016/17. Thus, this study was carried out with the objective of selecting superior faba bean varieties on farmers' fields with the participation of farmers at four districts in South Ethiopia. Farmers were provided with five improved varieties, which they compared with their own ones or respective local variety were evaluated and selected for desirable attributes following a randomized complete block design with three replications. In this participatory approach, farmers used different criteria to assess faba bean varieties at the flowering, maturity and harvest crop growth stages. Major selection criteria included stand establishment, plant height, maturity, seed size, leaf shading, suitability for intercropping, number of pod, number of branches, stem strength, disease & pest resistance, straw yield and grain yield. Farmers preferred faba bean varieties Dosha, Bobicho-04, Tumsa and Gabalicho for their high yielding, large seed size and disease tolerance. The combined analysis showed Dosha was the best yielder with seed yield 2850 kg/ha followed by Bobicho-04(2800 kg/ha),Tumsa (2733.3 kg/ha), Gabalicho (2716.7 kg/ha), Walki (2416.7 kg/ha) and local variety (1816.7 kg/ha). The yield advantage range from 33 % (variety walki) to 56.9 % (variety Dosha) over the local variety. Overall, the results showed that farmers had knowledge to make decision of the preferred superior varieties compared to the ones currently grown by farmers. Farmers mostly preferred varieties which combined high yield, disease resistance, large seed size and resistance to lodging. Thus, the selected varieties need to be multiplied and distributed to farmers in order to improve yield and varietal diversity.
Keywords: Faba bean, selection, varieties, criteria, participatory approach

Introduction

Faba bean is one of the most important cool-season food legumes grown in the highlands of Ethiopia. The crop has a multipurpose use and is consumed as dry seeds, green vegetable, or as processed food. Its products are rich source of high-quality protein in the human diet, while its dry seeds, green haulm and dry straw are used as animal feeds (Sainte, 2011). It is dominant pulse crop in Ethiopia which occupies about 443,107.88 hectares of land with estimated annual production of 838943.89 tons (CSA, 2014/2015). In Ethiopia, faba bean is the most important protein source for the rural people and used to make various traditional dishes. In addition to this, Desta, (1988) reported that it can restore soil fertility through fixing atmospheric nitrogen and provides large cash for producers and foreign exchange for the country.

Even though faba bean is important crop as national and internationally, the production and productivity of faba bean in Southern Ethiopia is low 1.64 t/ha (CSA, 2015) due to poor participation of farmers in the selection process, lack of improved varieties, poor agronomic practice, diseases and insect pests (Degife and Kiya,2016). Some improved faba bean varieties has been released by the different regional and federal research centers in the nation but farmers are still stress on few local faba bean varieties. Farmers have little information about the released varieties both agronomic practice and their economic importance because the varieties were released without the involvement of farmers and the released varieties had not yet evaluated in the study area. To improve the problem, participatory variety selection is the better option to fit the crop bring together of both target environments and user preferences. Participatory varietal selection is being conducted in many crops like chickpea (Goa et *al*., 2017), common bean (Gurumu, 2013; Alemayehu & Rahel, 2015), Bread wheat (Demelash *et al*., 2013) and Maize (Taddesse *et al*., 2014). Danial *et al.* (2007) reported that farmers' selection criteria vary with environmental conditions, traits of interest, ease of cultural practice, processing, use and marketability of the product, ceremonial and religious values. Farmers in Duna and Sodo zuria as well as farmers Cooperatives of Angacha and Doyogena districts are highly demanding better yielding varieties to maximize their production and to multiply in large scale, which consecutively increase income and improve the livelihood of their families or members. Therefore, the **objectives** of this study were to evaluate and select best performing faba bean variety/ies and to identify farmers' preferences and selection criteria to the study sites of Southern Ethiopia with the participation of farmers.

Materials and Methods

Description of Experimental Sites

On farm experiments were carried out at the mandate areas of Areka Agricultural Research center, Duna,Angacha,Doyogena and Sodo zuria of South Ethiopia during the 2016/2017 Meher season of each site. Duna (Andegna Otoro kebele) is located about 42 km far from the Hosanna town (the capital of Hadiya zone) at 0720.707'N; 03735.554'E; above sea level with an altitude of 2,666m. It receives mean annual rainfall of 1196.22mm and the temperature range from 10^{o}C to 18^{o} C in a wet season and 20^{o}C to 25^{o} in a dry season (Tsedeke Tadesse, 2015). Doyogena is located 171 km in south west of Hawassa, the capital city of the region of SNNP and 258 km south of Addis Ababa and lies at a latitude 7^{0}18'25"N-7^{0}21'49"N, longitude 37^{0}45'33"E-37^{0}48'51" E with an altitude ranging from 2300 to 2800 meters above sea level . It receives mean annual rainfall of the area ranges from 1200 to 1800mm and mean annul temperature of the area is 16^{0}C and red and black clay loams soil (Tsegaye Fitebo, 2014**).** The sites in Waraza lasho kebele of Sodo zuria woreda is lies at a latitude 6^{o}51'36"N , longitude 37°45'41"E with an altitude 1961 m above sea level and Angacha represent mid to high altitude at range of 1501-3000 m.a.s.l. Average annual rainfall is ranging between 1051.9 mm and 1341.5 mm for Sodo zuria, 1000mm to 1400 millimeters for Angacha. The annual mean temperature is 15.3^{o}C for Sodo zuria and the mean annual temperature ranges from 12^{0}c to 16^{0}c for Angacha (Abera Abebe, 2013; Biruk Seifu, 2013).

Experimental materials

In the study five improved faba bean varieties (Dosha, Walki, Bobicho-04, Tumsa and Gabalicho) including the local variety were evaluated for their adaptation and yield during 2016/17 main cropping season across four districts.

Experimental Design

The experiment was planted in a randomized complete block design on three farmers' fields where each farmer's field was used as replicate in each of the four districts. The experimental land size of each farmer was 21 m x 17 m with a plot size of 10 m x 5 m. The spacing between rows and plants was 40 cm x 10 cm.

Technology evaluation and selection methods

Participatory variety evaluation and selection experiment was conducted on farmers' field at four sites were implemented on farmers' fields to create awareness about the faba bean varieties. The participatory variety evaluation and selection of the trials was followed participatory approach by involving individual /or a group of farmers; seed multiplying farmers' cooperative; Agricultural extension officers, Agricultural transformation Agency (ATA) and South seed enterprise were participated in the PVS (Participatory variety evaluation and selection) process during field day/visit. Farmers and relevant stake holders have evaluated and ranked the cultivars/varieties at different growth stages of the crop. They used parameters like stand establishment, branch number, disease & pest resistance , pod number, seed number, seed size, Straw yield (animal feed), stem strength , Earliness/maturity and grain yield to evaluate the cultivars. The activity was jointly monitored by researchers, woreda agricultural experts, Durame seed quality control and development agents (DA's).

Data Collected

Agronomic data were collected on plant and plot basis from PVS trial. The data on number of pods per plant, number of seeds per pod, and plant height (cm) were taken and evaluated on five plants from each plot. Data like days to 50% flowering, days to maturity and seed yield (g) were collected from whole plot area. Farmers' preference data such as seed number, seed size, Straw yield (animal feed), stem strength, Earliness/maturity and grain yield were collected.

Data analysis

All data recorded by farmers in the different districts were synthesized and compiled for analysis of variance using SAS package. Means were separated using the Least Significant Differences (LSD) at 0.05 probability level.

Results and discussion

Performance Evaluation of Faba bean varieties

Mean grain yield of the tested varieties ranged from 1933.3 Kg/ha for local variety to 3466 Kg/ha for Tumsa with over all mean value of 2744.4 Kg/ha at Duna. The grain yields obtained from Dosha, Tumsa, Bobicho-04 and Gabalicho was significantly ($P < 0.05$) higher than that from local variety. At Angacha among the tested varieties; mean grain yield (kg/ha) ranged from 3200 for variety Dosha to 1933.3 for local variety. In Doyogena district, the highest grain yield was recorded on Dosha (3733.3 kg/ ha) followed by Bobicho-04 (3533.30 kg/ ha);

whereas the lowest was recorded on local variety (2200 kg/ ha). Similarly at Sodo zuria woreda varieties Walki (1866.7kg/ha), Gabalicho (1800kg/ha) and Tumsa (1733.3kg/ha) had the maximum grain yield than the rest of the varieties (Table 1).

Table 1: Means in Yield (kg/ha) of Faba bean PVS at different district in 2016/2017

	Yield (kg/ha)				
Varieties	Duna	Angacha	Sodo zuria	Doyogena	Mean
Bobicho-04	2866.7ab	3133.3ab	1666.7ab	3533.3a	2800a
Walki	2266.7bc	2200cd	1866.7a	2533.3b	2416.7b
Tumsa	3466.7a	2600bc	1733.3a	3400a	2733.3ab
Dosha	3000ab	3200a	1466.7b	3733.3a	2850a
Local	1933.3c	1933.3d	1066.7c	2200b	1816.7c
Gabalicho	2933.3ab	2666.7abc	1800a	3466.7a	2716.7ab
Grand mean	2744.4	2622.2	1600	3144.4	2555.6
CV (%)	18.56	12.11	9.13	12.38	16.39
LSD	*	**	**	**	**

The analysis of variance (ANOVA) indicated the presence of significant ($P < 0.01$) differences among the faba bean varieties for days to maturity, plant height and grain yield. But number of seeds per pod, number of pods per plant and days to flowering have no statistically significant difference among the varieties (Table 2). Mean grain yield of the tested varieties ranged from 1816.7 Kg/ha for local vaiety to 2850 Kg/ha for variety Dosha with over all mean value of 2555.6 Kg/ha. The grain yields obtained from Dosha (2850 kg/ha), Bobicho-04(2800kg/ha), Tumsa (2733.3 kg/ha) and Gabalicho (2716.7 kg/ha) was significantly (P< 0.01) higher than that from the local cultivar and had yield advantage of 56.9%, 54.1%, 50.5% and 49.5 % over local check (1816.7 kg /ha), respectively. Gabalicho and local cultivar were the tallest and the shortest of all the varieties, respectively. Bobicho-04 and local were the earliest maturing of all the varieties tested with 149 days each, whereas with 152 days, Tumsa and Gabalicho were the late maturing varieties. Bekele (2016) reported that local variety is early maturing variety while Gebalicho is late maturing. The result disagree with the finding of Ashanafi and Makuria (2015) that variety Hachalu was took longer maturity date than Gabalicho. The highest number of pod per plant was recorded by Dosha (33.58) followed by Tumsa (33.55); whereas the lowest was recorded by local variety (30.04). The mean number of seed per pod ranged from 3.06 for local to 3.83 for Walki and Tumsa (Table 2).

Table 2: Means of Yield and Yield Component traits of Faba bean PVS across districts in 2016/17

Varieties	**FD**	**DM**	**PLH**	**NPP**	**SPP**	**YKG**	**YAL (%)**
Bobicho-04	54	149.5c	159.95b	32.22	3.47	2800a	54.1
Gabalicho	54.7	152.3ab	168.3a	32.48	3.45	2716.7ab	49.5
Walki	56.33	151.3abc	154.92bc	27.87	3.83	2416.7b	33
Tumsa	54.3	152.8a	164.03a	33.55	3.83	2733.3ab	50.5
Dosha	55.2	150.8 bc	154.03bc	33.58	3.27	2850a	56.9
Local	50.8	149.3c	150.6c	30.04	3.06	1816.7c	
GM	54.2	150.9	158.3	31.8	3.33	2552.8	
CV (%)	8.4	1.58	3.5	29.8	9.9	16.39	
LSD	ns	**	**	ns	ns	**	

Where: ** = highly significant at 1% probability level, *= significant at 5% probability level, ns= non-significant at 5% probability, YAL=yield advantage over local DF = days 50% flowering, DM = days to physiological maturity, PLH = plant height, NPP=number of pod per plant, SPP=number of seed per pod and YKG= grain yield (Kg/ha)

Association among the Studied Characters

Grain yield is the most complex trait and it is influenced by genetic and environmental factors that determine productivity of the cultivars. Therefore, understanding of inter-relationships of grain yield and other traits are highly important for formulating selection criteria. Correlation coefficients among phenological and agronomic traits of the tested faba bean varieties are indicated in Table 3. Days to 50% flowering had positive and significant correlation with days to physiological maturity (r= 0.51**) and grain yield (r=0.52**). Days to 50% flowering had positive and non-significant association with plant height (r=0.11ns) and number of pod per plant (r=0.067ns). Grain yield had positive and highly significant correlation with number of seed per pod (r=0.28**). These results gave a clear indication that the yield components were mutually very closely associated. This is in agreement with those obtained by Taddese et al. (2011) and Yassin (1973). Grain yield had positive and highly significant correlation with plant height (r=0.51**), days to 50% flowering(r=0.52**), days to maturity(r= 0.38**), number of seed per pod ((r=0.28**) (Table 3). This result was in close agreement with previous findings by several authors (Taddesse *et al.*, 2011; Yassin, 1973) where grain yield was reported to have been

strongly associated with the major yield components. Similarly, the findings of Vandana and Dubey (1993) in respective of positive association of seed yield per plot with plant height, pods/plant and number of seeds/plant are in line with the present study.

Table 3: Simple correlation coefficients (r) for agronomic traits of the tested faba bean PVS across districts in 2016/17

Characters	DF	DM	PLH	NPP	SPP	YKG
DF	X	0.51**	0.11ns	0.067ns	0.27*	0.52**
DM		X	0.12ns	0.46**	0.58**	0.38*
PLH			X	0.14ns	0.22ns	0.51**
PPT				X	0.35**	0.21ns
SPP					X	0.28*
YKG						X

Where: ** = highly significant at 1% probability level, *= significant at 5% probability level, ns= non-significant at 5% probability, DF = days 50% flowering, DM = days to physiological maturity, PLH = plant height, NPP=number of pod per plant, SPP=number of seed per pod and YKG= grain yield (Kg/ha)

Farmers Variety Evaluation and Selection

The farmers who participated and evaluated the trial were representative to the area and having long experience in farming. Before beginning of the selection process, selected farmers from the districts were asked to set their priority selection criteria. Selection criteria of farmers in the study area were based on an extensive discussion and agreement and farmers set criteria during flowering, maturity and harvest stage of the crop. Participatory varietal evaluation and selection was done in the study district not only because farmers' cultivars were old, but also none of these tested varieties were previously grown by farmers. Thus, the criteria farmers used in identifying the suitable varieties depend on the existing constraints and opportunities farmers faced in their vicinity. Accordingly, grain yield, Stand establishment, Branch number, Pod number ,Seed number, plant height, Earliness/maturity ,Disease resistance ,Leaf shading ,Aphid resistance, Stem strength ,large seed size ,Marketability ,Suitability for intercropping & Straw yield were identified as the most important farmers' selection criteria. Individual farmers and' cooperative members scored each variety for individual traits considered important by them and ranking of varieties were done on a scale of 1-6, 1 being the highest score representing superiority and 6 being very poor. Researchers and DAs personnel were assist farmers during scoring. The farmers also provided overall score for each genotype based on all important traits.

Fig.1. Participants evaluating and selecting faba bean PVS during field day

Field days/visits were conducted in the four districts, 390 farmers, cooperatives and other stake holders individually or in a group scored the faba bean varieties in different sites. There were 150 (17 women& 133men), 180 (147 men & 33women), 20 (18men& 2women) and 40 (37 men &3 women) farmers, cooperatives and relevant stake holders involved in scoring of the trials in Doyogena, Angacha, Duna and Sodo zuria sites. Farmers and farmers cooperative evaluating and selecting different faba bean varieties (Fig.1). Considering practicality and more farmers included in the evaluation, small groups of 10–15 farmers were formed. About three farmers' cooperative members (Amacho wato; Hawora Arara and Utge cooperatives) and Zeret Union officials and five farmers cooperatives namely Mesena, Hambaricho wasara, Bondena, Tambo Otona & Pandide cooperatives were involved in variety selection at Doyogena and Angacha districts, respectively. The key criteria

used by farmers to evaluate and select the preferred varieties were grain yield, disease resistance, grain size and lodging resistance. Farmers, Agricultural experts and Researchers visiting six faba bean varieties in Duna (Fig.2).

Fig.2. Farmers, Researchers and extension workers visiting Faba bean PVS plot in Andegna Otoro, Dunaa

Grain yield was considered as the most selection criteria for each faba bean varieties and this is also in agreement with varietal selection of faba bean reported by Bekele (2016) and Alemayehu and Rahel (2015) for common bean varietal selection. Based on farmers selection criteria comparison was conducted among the tested faba bean varieties. Preference scores varied greatly among the farmers for each variety in each district (Table 4). Based on mean overall score the most preferred varieties were Tumsa,Dosha,Bobicho-04 and Gabalicho for Duna district; Dosha,Bobicho-04,Gabalicho and Tumsa for Doyogena; Walki, Bobicho-04, Dosha and Tumsa for Sodo Zuria and Bobicho-04,Dosha,Gabalicho and Tumsa in Anagacha (Table 4). In the Sodo zuria district, a greater number of farmers selected faba bean variety Walki as a better choice than other test varieties. This underlines the importance of testing of improved varieties in farmers' fields across districts.

In overall scoring and ranking of faba bean PVS variety Dosha was considered as best variety followed by Bobicho-04, Gabalicho and Tumsa (Table 4). The local variety was the least ranked variety because of less productivity per unit area. Variety Dosha ranked first because of higher productivity, stem strength, disease resistance and tilling capacity. Most faba bean varieties ranked significantly superior to local variety in each district. The farmers always ranked the improved varieties significantly superior to local variety for grain yield, yield components and disease resistance. The faba bean varieties were identified for their morphological performance and pairwise ranked as indicated in Table 5. Hence, in pair wise ranking of faba bean varieties Dosha was considered as best varieties, whereas the local variety as the least preferred variety by farmers Table 5. Overall preference score based on data from all sites showed the most preferred genotypes were Dosha, Bobicho-04, Gabalicho and Tumsa, while the least varieties was local variety (Table 4 & 5). Walki had an average preference in terms of mean score but the scores were inconsistent among the groups of farmers. This result indicated that Dosha, Bobicho-04, Gabalicho and Tumsa were farmers' and Researchers best preferred and top performed variety which can be considered as a promising variety to be widely produced by faba bean farmers

Table 4. Ranking and scoring of faba bean variety selection criteria (1-15) by farmers at four districts

Varieties	**Duna**			**Angacha**			**Soddo zuria**			**Doyogena**			
	Total score	Mean score	Rank	Total score	Mean score	Rank	Total score	Mean score	Rank	Total score	Mean score	Rank	Over all rank
Bobicho-04	47	3.6	4	27	1.8	1	33	2.36	2	39	2.8	3	2
Walki	51	3.9	5	76	5.1	6	31	2.2	1	58	4.1	5	5
Tumsa	30	2.3	1	64	4.3	5	47	3.36	4	54	3. 9	4	4
Dosha	33	2.5	2	32	2.1	2	46	3.29	3	26	1.9	1	1
Local	64	4.9	6	60	4.0	4	70	5	6	70	5	6	6
Gabalicho	43	3.3	3	45	3.0	3	54	3.86	5	34	2.4	2	3

Scoring of farmers selection criteria was based on a ranking scale from1-6, with 1 as the most important to 6 as the least important ,**NB:1-15 f**armers' selection criteria set ; 1= Stand establishment 2=Branch number ,3=Pod number ,4=Seed number,5= Plant height ,6= Earliness/maturity ,7=Disease resistance ,8=Leaf shading ,9=Aphid resistance, 10=Stem strength ,11=Seed size ,12=Grain yield ,13=Marketability 14=Suitability for intercropping & 15= Straw yield (animal feed)

Table 5: Pairwise ranking of faba bean varieties based on farmers selection criteria

Characters	Bobicho-04	Gabalicho	Walki	Tumsa	Dosha	Local variety
Bobicho-04	X	Bobicho-04	Bobicho-04	Bobicho-04	Dosha	Bobicho-04
Gabalicho		X	Gabalicho	Gabalicho	Dosha	Gabalicho
Walki			X	Tumsa	Dosha	Walki
Tumsa				X	Dosha	Tumsa
Dosha					X	Dosha
Local variety						X
Total score	4	3	1	2	5	0
Rank	**2**	**3**	**5**	**4**	**1**	**6**

CONCLUSION AND RECOMMENDATION

Farmers used different parameters and methods to evaluate the tested faba bean varieties. For fast adoption and dissemination the new variety/ies considering the preferences of farmers and consumers are necessary, otherwise it is less likely to be widely accepted by the farming community. In this study farmers ,stakeholders 'and breeders evaluation and selection were confirmed that Dosha, Bobicho-04, Tumsa and Gabalicho were found good for yield potential and other agronomic traits among the six tested genotypes based on both farmer's and Researchers evaluation. According to the analysis result and farmers' selection variety Dosha, Bobicho-04, Tumsa, and Gabalicho were best performing with grain yield and yield components. All the selected varieties have large seed size which has good marketability. Therefore, these selected varieties will be scale up for the next cropping season at the tested area and similar agro ecology.

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