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Effect of Faba Bean (*Vicia faba* L.) Varieties on Yield Attributes at Sinana and Agarfa Districts of Bale Zone, Southeastern Ethiopia

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Abstract

Field experiments were conducted at Agarfa and Sinana Districts, south eastern part of Ethiopia with the objective of to evaluate high yielding faba bean varieties during the main cropping season of 2014. The following Eight improved faba bean varieties Mosisaa, Moti, Gebelcho, Hachalu, Shallo, Tumsa, Wolki and Degaga were used for evaluating their performance and the following data were recorded: effective tiller per plant, plant height, pods per plant, grain per pod, days to 90% physiological maturity, 100 grain weight, and grain yields were taken from the middle three rows and ten sample plants. The result revealed that there is a variation between the varieties for most yield and yield components. In both locations, maximum pods per plant were recorded from Degaga variety (20.39 and 22.6), whereas lowest number of pods were counted at Hachalu (12.46) and Tumsa (11.67) varieties at Agarfa site from Gebelcho variety (13.46) at Sinana experimental site. The maximum 100 grain weight was recorded from Gebelcho variety (94.33) at Sinana and Hachalu variety (80.33) at Agarfa experimental site. In both locations, the maximum harvesting index and grain yield were recorded at Shallo variety with 44.76%, 43.85% 4886.8 kg/ha and 4701.6 kg/ha at Agarfa and Sinana, respectively, while minimum grain yield was recorded from Hachalu and Moti varieties with 3436.2kg/ha and 3703.7kg/ha yield at Sinana and Agarfa district, respectively. Therefore, from the result we conclude that Shallo variety was performed good yield and recommended to the local farmers.

Keywords: *Faba bean varieties, Grain yield, yield attribute.*

1. Introduction

Faba bean (*Vicia faba* L.) is also referred to as broad bean, horse bean and field bean and it is the fourth most important pulse crop in the world (Sainte, 2011). The crop has a multipurpose use and is consumed as dry seeds, green vegetable, or as processed food. Its products are a 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). Faba bean seeds are used for human nutrition. The grain of faba bean contains a high protein content of 24-33% (Winch, 2006). Faba bean varieties that are used for human nutrition belong to the *V. faba* major botanically whereas the V. faba minor and *V. faba* equina are botanical types used for animal feeding (Monti et al., 1991).

Ethiopia is the world's second largest producer of faba bean next to China; its share is only 6.96 % of world production and 40.5 % within Africa (Chopra *et al*., 1989). In Ethiopia, the average yield of faba bean under small-holder farmers is not more than 1.6 t ha-1 (CSA, 2013), despite the availability of high yielding varieties (> 2 t/ha) (MoA. 2011). Demand is growing, fuelled by rapid population growth, and the gap between supply and demand continues to increase (ICARDA, 2008). In Ethiopia, the faba bean production is primarily a rain-fed system and it is also reducing the poverty by, 3% for adopter households moved up at least one 'wealth class', while all non-adopters remained in the lowest class (ICARDA, 2008).

Faba bean ranks first in pulse crop in the total area coverage and the total production of Ethiopia. It accounts about 36% of the country's pulse production (IFPRI, 2010). Currently, the total area, under cultivation with faba bean in the country, is estimated to be about 0.54 million hectare and the total production is 696 million kilogram (MoARD, 2009). Oromia region is the largest (320 million kilogram quintal) faba bean producer in the country followed by Amhara region 250 million kilogram (CSA, 2011). The two regions together share about 85% of the country's faba bean production. Due to its nitrogen fixing capacity, it is used in crop rotation with important cereal crops like wheat, teff, barley and other crops (IFPRI, 2010).

Farmers who adopted the new faba bean technologies, whether the full package or individual components, obtained significantly higher yields. Simply replacing traditional varieties with improved ones led to gains of 18% in Egypt, 8% in Sudan and 42% in Ethiopia (ICARDA, 2008). Levels of soil-borne diseases (like crown rot) and pests like root lesion nematode of wheat are reduced by growing faba bean as a break crop. Growers claim that the soil tilth is improved after faba bean growing (ICARDA, 2008).

The productivity of faba bean in Ethiopia is quite lower 15.2 qt/ha (CSA, 2011) than UK 30qt/ha (Winch, 2006). Most farmers in Ethiopia cultivate local faba bean varieties (Thijssen et al., 2008). Faba bean varieties, combining disease resistance with desirable traits like large seed sizes and high yield, are more preferred by the farmers (Boef and Ogliari, 2008). In Ethiopia, there are about 20 improved faba bean varieties which are adapted to different agro-ecology and have different disease reaction (IFPRI, 2010). Local varieties are low yielding and susceptible to both biotic and abiotic factors. Samuel et al. (2008) reported that most local faba bean landraces are highly susceptible to disease and low yielding. The reasons for the decline the productivity of faba bean is due to susceptibility to biotic (Sillero et al., 2010) and a biotic stresses (Link et al., 2010).

Bale District is one of the production areas of faba bean in Ethiopia for green and dry seed. Evaluation of high yielding variety is very important for farmers to sustain their production. The production of faba bean is affected by the lack of improved varieties and the local varieties are susceptible to certain biotic and abiotic factors. Bale area is a wheat belt of the country. The production of wheat is currently being challenged due to the monocropping practice which causes infestation and build-up of pests and diseases which in turn affect the productivity of wheat. This raises the issue of sustainability in livelihood as a result of which the tendency for food security can be jeopardized. Hence, growing of other alternative crop species like faba bean as a rotation crop is very important. Evaluation of improved faba bean varieties is among the major measures to be considered to resolve the existing problems of faba bean production and to boost the productivity of the crop. Therefore, the experiment was conducted to evaluate faba bean varieties for yield and yield components at Sinana and Agarfa District of Bale Zone.

2. Materials and Methods

The experiments were conducted at Sinana and Agarfa districts of Bale Zone, South-eastern part of Ethiopia during the main cropping season of 2014. The center represents highlands of Bale Zone with high rainfall and characterized by bimodal rainfall types. The main cropping season is locally known as *Ganna* extends, from half of July to September and the other cropping season was locally called *Bona* extends from March to July. In both locations, the dominant soil type is clay soil and slightly acidic with a Ph of 6.5.

Table 1. Geographical and Climatic condition of districts during cropping season.

District	Attitude	Temperature	Rainfall
Sinana	2361 – 2396	24.2°C to 9.4 °C	823mm
Agarfa	2404 – 2501	24.75°C to14.75°C	880mm

2.1. Treatments and Experimental Design

Eight improved faba bean varieties were collected from different research centers of Ethiopia and evaluated for their performance at Bale. The experiment was conducted by RCBD design with three replications and a plot size of 2.4m x 3.1m. To reduce the inter plot effect, the space between plots and blocks were adjusted at 0.5 and 1m, respectively. There were five rows per plot and 30 bean seeds were sown in a single row. Intra and inter spacing were 10 cm and 40 cm, respectively. The experiment was conducted with the following varieties: Wolki (EH96049-2), Degaga (R878-3), Moti (EH95078-6), Tumsa (EH99051-3), Hachalu (EH00102-4-1), Gebelcho (EH96009-1), Shallo (EH011-22-1) (MoARD, 2009) and Mosisaa (EH-99047-1) (SARC, 2013).

At the time of planting, all plots received a basal application of Diammonium Phosphate (DAP), (18% N, and 20% P) at the rate of 100 kg ha^{-1}. The experimental fields and experimental units were managed as per the recommended practices for faba bean.

2.2. Data Collection

The following data were collected from the middle three rows and from sampled ten plants in each plot.

- Productive tiller: Numbers of effective tillers were counted at poding stage.
- Plant height (cm): Length of the central axis of the stem, measured from the soil surface up to the tip of the stem.
- Number of pods per plant: was taken from 10 randomly selected plants from the middle rows of each plot at harvest.
- Number of grains per pod: Average numbers of grains per pod were counted at harvest.
- Hundred grain weight (g): sampled from the composited seeds of each plot and weighed after it had been adjusted to 10% moisture level by oven dry method.
- Days to 90% physiological maturity: it was recorded when 90% of the plants in the plot are mature enough.
- Dry Bio mass was harvested at crop maturity from the above ground part of net plot.
- Harvest index (HI) was calculated as the percent

$$HI = \frac{\text{Grain Yield}}{\text{Total biomass yield}} * 100$$

  proportion of grain yield to total above ground DM yield (Fleischer *et al*. 1989).
- Grain yield (Kg/ha): The grain yield per hectare was determined by harvesting all plants from net plot area and converted on hectare basis.

2.3. Data Analysis

Collected data were subjected to analysis of variance with SAS computer software version 9.1.3 (SAS, 2003). Means were compared with Least Significance Difference

(LSD) at 5% probability level. The correlation analysis conducts as the procedure of SAS Proc corr. Procedure

3. Results and Discussion

The result from the experiment revealed that there is a variation between the varieties for various growth, yield and yield component parameters. However, there is no significance difference (P< 0.05) between the varieties for parameters like number of effective tillers, days to 50% flowering, days to 50% emergence and number of seeds per pod for both locations.

3.1. Number of Pods per Plant

Statistical analysis showed that faba beans varieties were significantly (P<0.05) affected pods per plant at both locations. The maximum pods per plant were recorded from Degaga (20.39 and 22.46, respectively, at Agarfa and Sinana) and it was followed by Shallo, Mosisaa, Moti and Tumsa in both locations Gebelcho at Agarfa experimental site and Hachalu at Sinana (Table 2 and 3). Whereas the smallest pods per plant were recorded at Tumsa and Hachalu varieties at Agarfa experimental site and Gebelcho variety at Sinana (11.67, 12.46 and 18.82) pods per plant, respectively. The result was in line with the work of Tafere *et al*. (2012) who reported that Degaga varieties had a higher number of pods per plant, while Gebelcho and Moti varieties had the smallest number of pods per plant. Hassan and Ishaq (1972) found that genotypes varied in their pod number per plant. Pilbeam *et al*. (1992) also reported that there was a variation between faba bean varieties for pod number per plant. Girma and Haila (2014) found that Degaga variety had the highest number of pods per plant while the result of Shallo variety was contradicting with this result which was lower in the number of pods per plant. The lowest number of pods per plant was recorded from Tumsa (11.67 and 18.82 at Agarfa and Sinana, respectively) and Hachalu varieties (12.46 and 16.46 at Agarfa and Sinana, respectively (Tables 2 and 3).

In this study number of pods per plant had a significant and positive correlation with seed per pod and days to 90% physiological maturity, while a negative correlation with plant height at both locations (Table 4).

Table 2. Effect of varieties on yield and yield component of faba bean at Agarfa site

Varieties	Tiller number	pod per plant	Seed per pod	Plant height	100g weight	Physiological Maturity	Dry matter Biomass (Kg/ha)	Harvesting Index %	grain yield Kg/ ha
Gebelcho	1.50a	15.67ab	3.00a	1.30a	80.33ab	126.6abc	11368.0abc	36.99bc	4362.2ab
Hachalu	1.45a	12.46b	2.92a	1.23a	83.10a	133.3a	9803.0c	40.95abc	4012.3b
Degag	1.50a	20.393a	2.96a	1.35a	56.13d	129.0ab	10190.4bc	39.25abc	3971.2b
Mosisaa	1.70a	16.29ab	3.04a	1.33a	64.12cd	119.67c	10167.9bc	42.9ab	4362.2ab
Moti	1.33a	13.29ab	3.29a	1.25a	79.60ab	119.67c	9935.0bc	37.38bc	3703.7b
Shallo	1.60a	16.75ab	3.04a	1.37a	60.48cd	124.3bc	10918.3bac	44.76a	4886.8a
Tumsa	1.40a	11.67b	3.04a	1.30a	79.80ab	130.67ab	11491.9ba	34.11c	3878.6b
Wolki	1.70a	17.21ab	3.04a	1.33a	69.33bc	133.3a	11865.3a	34.45c	4104.9b
LSD	0.37	5.67	0.45	0.16	11.01	7.04	18.71	10.24	760.25

Means with the same letter at the same column are not significantly different.

Table 3. Effect of varieties on yield and yield component of faba bean at Sinana site

Varieties	Tiller number	pod per plant	Grain Per pod	Plant height/m	100g weight	Physiological Maturity	Dry matter Biomass (Kg/ha)	Harvesting Index%	Grain yield (Kg/ ha)
Gebelcho	2.67a	13.46b	3a	1.28c	94.33a	128.3ab	10473.4ab	35.74ab	3703.7ab
Hachalu	2.79a	16.46ab	2.92a	1.33b	86.33ab	134.0a	8901.0b	38.61ab	3436.2b
Degag	2.92a	22.46a	2.96a	1.34b	59.13d	127.67ab	10029.0ab	37.58ab	3765.4ab
Mosisaa	2.96a	21.88a	3.04a	1.33bc	74.93bc	121.3b	10072.5ab	42.47a	4269.6ab
Moti	2.75a	16.54ab	3.29a	1.37ab	76.33bc	128.0ab	10059.7ab	36.4ab	3621.4b
Shallo	2.42a	20ab	3.04a	1.42a	65.77dc	126.67ab	10793.6ab	43.58a	4701.6a
Tumsa	2.75a	18.82ab	3.04a	1.35b	82.6b	128.0ab	11469.9a	30.81b	3497.9b
Wolki	2.33a	19.83ab	3.04a	1.38ab	66.07dc	134.67a	10670.0ab	38.48ab	4074.1ab
LSD	0.65	7.0	0.5	0.054	11.48	11.36	1959.6	15.82	1045.4

Means with the same letter at the same column are not significantly different.

3.2. Plant Height

Statistical analysis showed that plant height had significantly (P< 0.01) affected at Sinana where as non-significant at Agarfa experimental site. At Sinana experimental site, the maximum plant height was recorded from Shallo, Moti and Wolki varieties with a height of 1.42m, 1.37m and 1.38m, respectively. Whereas, the shortest plant heights were recorded at Gebelcho and Mosisaa varieties with 1.28m and 1.33m height, respectively (Table 3). Therefore, these varieties are considered as dwarf varieties. The result was in line with the work of Tafere et al. (2012) who reported that a Gebelcho verity was the shortest variety. Talal and Munqez (2013) reported that plant height was significant affected by faba bean accessions. Della (1988) found that plant height of faba bean genotypes varied significantly under rain fed conditions.

Plant height had a positive and significant correlation with pods per plant (r=0.54 and r=0.58) and a negative and significant correlation with seed per pod (r=-0.33 and -0.39), respectively at Sinana and Agarfa Districts.

3.3. Days to 90% Physiological Maturity

A significant difference (P<0.05) was observed among faba bean varieties for days to 90% physiological maturity at both locations. The maximum days to 90% physiological maturity was recorded from Wolki (134.7) and Hachalu (134.0) varieties at Sinana district. The minimum days to 90% physiological maturity was recorded from Mosisaa (121.3) and Shallo (126.7) varieties. On the other hand, the maximum days to 90% maturity at Agarfa district was observed from Wolki (133.3) and Hachalu (133.3) varieties, while the lowest was recorded from Mosisaa (119.7) and Moti (119.7) varieties. Generally, this result indicates that varieties like Hachalu and Wolki are late maturing varieties, while Mosisaa and Moti are early maturing varieties at both locations (Tables 2 and 3). Tafere et al. (2012) reported that Moti is early maturing variety while Gebelcho is late maturing. Talal and Munqez (2013) found that a significant variation was observed among accessions from days to fruit setting. The result disagrees with the work of Girma and Hail (2014) who found that faba bean varieties were non-significant on the physiological maturity in both irrigated and rain fed condition.

3.4. Hundred grain weight of Faba bean varieties

A hundred grain weight of faba bean was significantly (p<0.05) affected in both locations. The maximum 100 grain weight was recorded on Hachalu (83.1), Gebelcho (80.33) Tumsa (79.8) and Moti (79.6) varieties at Agarfa district. While, the lowest average 100 grain weight was recorded on Degaga and Shallo varieties with average 100 grain weight of 56.13 and 60.48, respectively (Table 2). On the other hand, the maximum 100 grain weight at Sinana was recorded from Gebelcho (94.33) and Hachalu (86.33) varieties, while the minimum 100 grain weight was from Degaga, Shallo and Wolki varieties with an average 100 grain weight of 59.13, 65.77 and 66.07, respectively (Table 3). This result revealed that Hachalu and Gabelcho varieties are large seeded, while Degaga and Shallo were small seeded varieties. Seed size is one of the important parameters for the choice of the varieties by the growers. Degaga variety has the largest number of seeds per pod, but it was small seeded; hence its yield was reduced (Tables 2 and 3). The result was in line with the work of Tamane et al. (2015) who reported that Moti, Tumsa and Gebelcho varieties were the higher 1000 grain weight while Degaga variety was the smallest grain weight. Girma and Haila (2014) reported that 1000 weight of Degaga variety was similar to Shallo variety and it was small.

3.5. Dry biomass

The statistical analyses showed that dry matter biomass had significant (p<0.05) different on faba bean varieties. The highest mean dry biomass weight (11469.9Kg/ha) recorded from Tumsa variety at Sinana district (Table 3). Similarly, the highest dry biomass weight was recorded from Wolki (11865.3Kg/ha) and Tumsa (11491.9Kg/ha) varieties at Agarfa district (Table 2). On the other hand, the lowest mean dry biomass was recorded from Hachalu variety with a dry biomass of 9935.0 and 8901.0 Kg/ha at Agarfa and Sinana District, respectively (Table 2 and 3). Abdalla *et al*. (2015)

reported that dry biomass was significantly varies with faba bean varieties. Comparatively, a higher dry biomass was noted from Agarfa District which may be attributed to the favorable conditions. Abdalla *et al*. (2015) and Toker (2004) reported the environments had significant effect on the dry biomass.

3.6. Harvest Index

In both locations, harvest index had significantly ($p<0.05$) affected on faba bean varieties. The maximum harvest index value was recorded from Shallo (43.58 and 44.76%) and Mosisaa (42.47 and 42.9%) varieties at Sinana and Agarfa District, respectively. Harvest index was significantly lower for Tumsa (30.81) variety as compared to Shallo variety at Sinana District, whereas there was no significant difference with the varieties (Tables 2 and 3). Similarly, the lowest harvest index was recorded from Tumsa (34.11%) and Wolki (34.45%) varieties at Agarfa District (Table 2). Gebremeskel *et al*. (2011) reported that the harvest index was significant for different faba bean varieties. Abdalla *et al*. (2015) also reported harvest index varies for different faba bean varieties. Contrasting results were reported by Agung and McDonald (1998) who stated that the harvest index differed little between genotypes. In this result, a higher grain yield producing varieties have a higher harvest index, while varieties which have a lower yield have a lower harvest index. A similar result was reported by Gebremeskel *et al*. (2011).

3.7. Grain Yield

The statistical analysis shows that a significant ($P<0.05$) difference was observed on grain yield of faba bean in both locations. In both locations, the maximum grain yield was harvested from Shallo variety which is (4886.8 kg/ha and 4701.6 kg/ha) at Agarfa and Sinana district, respectively (Tables 2 and 3). Similarly, the highest grain yield was obtained from Gebelcho (4362.2 kg/ha) and Mosisa (4362.2 kg/ha) varieties at Agarfa district, while the smallest grain yield was recorded at the varieties of Moti and Tumsa varieties with average grain yield of 3703.7 and 878.6 kg/ha (Table 2). Following Shallo variety higher yield was obtained from Mosisaa and Wolki varieties at Sinana district with average grain yield of 4269.6 and 4074.1 kg/ha, respectively. On the other hand, the minimum grain yield at Sinana district was recorded from Hachalu (3436.2) and Tumsa (3497.9 kg/ha) varieties (Table 3). The result was in line with Tafere et al. (2012) who reported that low grain yield was harvested on Moti varieties, but in the current finding Moti was a low yielding variety. ICARDA (2008) indicates that replacing of traditional varieties with improved ones led to gains of 18% in Egypt, 8% in Sudan and 42% in Ethiopia. Tamane et al. (2015) reported that Degaga variety was the higher grain yield as compared to Moti, Tumsa and Gebelcho varieties. ICARDA (2010) reported that Wolki variety can increase the grain yield up to 70-100% as compared to a local check. In the current finding, there is 24.2 % increment of yield for using Shallo variety (high yielder) as compared to Moti variety (low yielder) at Agarfa district. Similarly, there were 26.91% increments of yield for growing Shallo variety in place of Hachalu variety. The result contradicts the result of Girma and Haila (2014) who found that Degaga variety was a higher grain yield while Shallo variety was a lower grain yield. This variation may be due the environmental variations and the varieties adapting to different ecological conditions. ICARDA (2010) reported that Shallo variety was a high yielder. Fekadu (2013) reported that Roba-1 faba bean variety was reducing faba bean yield by 4.2%, whereas Awash-1 faba bean variety increasing faba bean yield by 24.3% as compared to the local check.

Combined analysis (Table 4) revealed that grain yield had positive and highly significant association with seed per pod ($r=0.84$ and 0.82) and dry biomass ($r=0.65$ and 0.61), respectively at Sinana and Agarfa Districts. This indicates that number of seed per pod had significant effect of grain yield of faba bean varieties.

Generally, there were correspondingly similar results for all faba bean varieties at both locations. However, except for the yield parameters there were larger values for most parameters were recorded from Sinana district. These indicate that Sinana site is more suitable for faba bean production.

Table 4. Correlation analysis among tiller number, pod per plant, seed per pod, Plant Height, 100grain weight physiological maturity, Dry Biomass, harvesting index and grain yield at Agarfa and Sinana District

	Parameter	Ti	Ph	Po	Se	Phi	Db
Agarfa	Ti						
	Ph	0.28 ns					
	Po	-0.37*	0.54*				
	Se	-0.18 ns	-0.33*	0.55*			
	Wt	-0.43*	-0.40 ns	- 0.63***	-0.11 ns		
	Phi	-0.19 ns	-0.11 ns	0.51*	-0.27 ns		
	Db	-0.51*	0.25 ns	0.12 ns	0.29 ns	-0.17 ns	
	Hi	0.28 ns	0.32 ns	0.27 ns	-0.29 ns	-0.51	-0.49**
	Gy	0.11 ns	-0.15 ns	0.15 ns	0.84**	-0.15 ns	0.65*
Sinana	Ti						
	Ph	0.25 ns					
	Po	-0.41*	0.58*				
	Se	-0.24 ns	-0.39*	0.59*			
	Wt	-0.42*	-0.21 ns	-0.59**	0.28 ns		
	Phi	0.026 ns	-0.41 ns	0.55*	0.1 ns		
	Db	-0.53*	0.28 ns	0.21 ns	-0.1 ns	-0.54*	
	Hi	-0.24 ns	0.37 ns	0.28 ns	-0.48 ns	-0.12 ns	-0.52*
	Gy	-0.019 ns	-0.30 ns	0.15 ns	0.82**	-0.14 ns	0.61*

Key: - Ti= tiller number, **Po**= pod per plant, **Se**=seed per pod, **Ph**= Plant Height, **Wt**= 100grain weight **Phi**=physiological maturity, **Db**= Dry Biomass, **Hi**= harvesting index and **Gy** = grain yield *$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$, ns= non-significant

4. Conclusion and Recommendations

The lack of improved varieties, which are well adapted to the farmers in the study area, was the main challenge for the farmers in the study area. Eight genetically modified varieties were evaluated for their yield and yield components faba bean at Bale Zone at Sinana and Agarfa districts. There were variations between the varieties for most of

The parameters and some varieties were performing well at both locations. The result indicates that there were slight variations for the varieties between the two locations. In both locations, the higher grain yield was harvested from Shallo variety which was followed by Gebelcho, Mosisaa and Wolki varieties where as Degaga variety was the lowest grain yield as compared to the other variety. Therefore, farmers located at Sinana and Agarfa Districts are recommended to use Shallo varieties to increase faba bean yield.

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