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Performance Evaluation of Improved Faba bean (*Vicia faba L.*) Varieties for Yield and Yield Attribute Traits in Highland Areas of West Hararghe, Eastern Ethiopia

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Abstract

Faba bean is a multipurpose pulse crop in Ethiopia. The objective of this study was to evaluate the adaptability and performance of recently released faba bean varieties. The field experiment was conducted on ten varieties in three faba bean growing areas of west Hararghe zone, eastern Ethiopia. The experimental materials were evaluated in randomized complete block design with three replications under rain fed conditions in 2021 main growing season. The combined Analysis of Variance (ANOVA) revealed that there was significant ($P<0.01$) difference among varieties, locations for most of the traits. The interaction of genotype by location (GEL was only significant for 50% days to flowering. Among the tested varieties, Wolki (3711.11 kg ha^{-1}), Gora (3616.67 kg ha^{-1}) and Didia (3608.89 kg ha^{-1}) were selected for maximum grain yield over locations. These varieties can be recommended for pre-extension demonstration in eastern part of Ethiopia.

Keywords: Faba bean; Adaptability; Varieties; Yield

Introduction

Faba bean is also known as broad bean that found on fifth rank under pulse crops world average production [1]. The global pulse crops data of 2008-2017, showed that the annual production of this crop is about 4.5 million tons in average [2]. Cultivated faba bean is used as human food in developing countries and as animal feed, mainly for pigs, horses, poultry and pigeons in industrialized countries [3]. It can be used as a vegetable, green or dried, fresh or canned [4]. It is a common breakfast food in the Middle East, Mediterranean region, China and Ethiopia. The most popular dishes of faba bean are Medamis (stewed beans), Falafel (deep fried cotyledon paste with some vegetables and spices), Bissara (cotyledon paste poured onto plates) and Nabet soup (boiled germinated beans) [5]. Feeding value of faba bean is high and is considered in some areas to be superior to field peas or other legumes [6-10].

In Ethiopia, faba bean is one of the earliest domesticated cool season food legumes. In the country a total production of 1.07 million metric tons and the average productivity of 2.12 ton ha^{-1} of faba bean were estimated [4]. However, in the country the potential productivity of faba bean reached up to 5 ton/ha [11]. The faba bean production and productivity is constrained by several biotic and abiotic stresses, of which lack of improved varieties, shortage of certified seeds, diseases such as rust, powdery mildew and root rot, insect pests such as aphids and low soil fertility are the major ones and becoming a major challenge to food security [12,13]. In the study areas, Low yielder of landraces, lack of improved varieties and associated improved management and protection practices are some of the major constraints.

Objectives

- To evaluate the adaptability and performance of recently released faba bean varieties.
- To identify the high yielder faba bean varieties across testing locations.
- To recommend the best performing faba bean varieties for tested areas.

Materials and Methods

Description of testing locations: The experiment was conducted in 2021 main cropping seasons at three locations of west Hararghe zone, Oromia region namely Kiliso, Arberekete and Hirna which known by faba bean production. Detailed description of the testing sites presented in Table 1.

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Testing Sites	Latitude	Longitude	Altitude m.a.s.l	Annum Rain fall. (mm)	Average Temperature (°C)	Soil Type
Kiliso	9°05′N	40°88′E	1856	950	15.0	Vertisol
Arberekete	09º06'N,	40º 91'E	2247	1150	14.0	Vertisol
Hirna	9°13′N	41°06′E	1763	1010.9	19.7	Vertisol

Key: m.a.s.l: mean above sea level, mm: millimeter and ºC: degree centigrade. The soil type of the testing sites is classified as black vertisol.

Table 1: Description of the three testing locations in 2021main cropping season.

Experimental materials, design and management: The total of 10 recently released faba bean varieties namely Degaga, Gora, Dosha, Gebelcho, Hachalu, Wolki, Moti, Tumsa, Chalew and Didia we used for the experimental trial. The seeds were sourced from national highland pulse coordinating of Holeta Agricultural Research Center in Ethiopia. The varieties were laid down in a randomized complete block design with three replications at each testing location. The plots were 4 rows of 3 m length with spacing of 40 cm and 10 cm inter and intra-row spacing respectively. The space between blocks and plots were 1.5 and 0.6 m, respectively. NPS fertilizer was applied during planting time at the rate of 121 kg/ha for initiation purpose. All other agronomic practices were applied equally to the experiment at each location (Table 2).

No	Varieties	Year of release	Origin	Source
1	Degaga	2002	Introduction	HARC
2	Gora	2012	Hybridization	HARC
3	Dosha	2008	Collection	HARC
4	Gebelcho	2006	Hybridization	HARC
5	Hachalu	2010	Hybridization	HARC
6	Wolki	2008	Hybridization	HARC
7	Moti	2006	Hybridization	HARC
8	Tumsa	2010	Hybridization	HARC
9	Chalew	2008	Hybridization	HARC
10	Didi'a	2014	Hybridization	HARC

HARC: Holeta Agricultural Research Center

Table 2: List of faba bean experimental materials.

Data collection and analysis: Data on days to 50% flowering, days to 95% physiological maturity, thousand seed weight and grain yield per plot converted to kg ha^{-1} were recorded on plot basis. Data on, plant height (cm), number of pods per plant and number of seed per pod were collected on individual plant bases using five randomly selected plants from the middle rows of each plot. The combined analysis of variance was done after the test of homogeneity of variance for each location using Levene's Test.

The linear mixed model was used in the analysis of variance combined over locations.

$Yijk=\mu+gi+ej+bk(j)j+(ge)ij+\varepsilon ijk$

Where: Yijk=the response of Y trait from the i^{th} genotype, grown in the k^{th} block of j^{th} location.

μ=Grand mean

gi=The effect of the ith genotype

ej=The effect of jth location

bk (k) j=The effect of kth block/rep in jth location.

(ge)ij=The interaction between the ith genotype and jth location.

εijk=Pooled error

All measured quantitative parameters were subjected to Analysis Of Variance (ANOVA) by using R.4.0.3 software to assess the significance of the difference between the varieties. Mean separation was carried out using Least Significance Difference test (LSD) at 5% probability level.

Results and Discussion

Analysis of variance: Levene"s test result revealed the error variance was homogeneous for grain yield and yield related traits for each three location and allowed to proceed further for combined analysis of variance across locations. The combined Analysis of Variance (ANOVA) for seven traits over locations revealed significant ($P< 0.01$) difference for Genotypes (G) and Locations (L) for most of traits and the Genotype by Location interaction (GEL) effects was also highly significant for days to 50% flowering (Table 3). The presence of significant variations among the genotypes indicates that the different inherent genetic potential of genotypes. Similar to this,

significance variation among genotypes for yield and related agronomic traits was reported Tadele, et al. [14-16].

Traits	Source of variation				
	Genotypes (G)	locations (L)	G × L	L × Block (B)	Polled error
Df	9	2	18	6	54
DTF	25.51**	1189.38**	12.62**	1.99ns	3.4
DTM	20.99**	53.68**	5.68ns	20.01**	6.09
PH	661.7**	10697.3**	273.6ns	683.9**	202.3
NPPP	2.74*	3.42*	0.89ns	0.10ns	8.97
NSPP	1.08ns	0.83ns	2.25ns	9.26ns	5.37
TSW	56959**	601ns	404ns	1877ns	2075
YLD	1279*	66427**	1820ns	3295ns	1218

**,*Significant difference at p=0.01 and p=0.05 respectively. Ns: non significance difference; DTF: Days to Tlowering; DTM: Days to Maturity; NPPP: Number of Pod Per Plant, NSPP: Number of Seed Per Pod, TSW: Thousand Seed weight and YLD: Grain Yield.

Table 3: Means squares from combined analysis of variance of traits across locations.

Days to 50% flowering: There was highly significant variation among genotypes and locations in days to 50% flowering. This indicates that the evaluating genotypes and testing locations were different in days to flowering and in environmental factors respectively. Varieties Didia (44.44 days), Gora (44.44 days), and Hachalu (44.33 days), had the longest days to flowering whereas, Tumsa (40.11 days) and Moti (40.22 days) (Table 4) had the shortest flowering dates that might escape the terminal drought stress. Similar to this, previous finding was reported by Kindie Y, et al..

Days to 95% physiological maturity: There was also a significant difference ($p<0.01$) among genotypes across locations in days to 95% physiological maturity. As Table 4 described that the longest mean number of days to maturity was registered for variety Wolki (112.44 days) followed by Gora (111.78 days), Hachalu (111.78 days), Didia (111 days) and Dosha (110.67 days) while, Tumsa (107.67 days) had the shortest days to maturity this might it suitable variety to moisture stress environments. In agreement to this result, recent finding was reported by Mesfin T et al.

Plant height (cm): A highly significant difference was measured for plant height among tested genotypes and between three locations (Table 3). The longest plant height was recorded for variety Wolki (150.91 cm) followed by Chalew (145.53 cm), Didia (144.02 cm), Hachalu (141.44 cm), Gebelcho (139.89 cm) and Dosha (138.4 cm) while, the shortest plant height was obtained for Degaga (121.74 cm). These varieties could have high vegetative mass which is important for increasing of grain yield. In line to this, previous investigations were reported by Mesfin T et al. and Zebire D, et al.

Number of pods per Plant: The significant differences ($P<0.05$) was obtained number of pods per plant among tested genotypes ($P<0.01$) (Table 3). The highest pod was recorded for varieties Wolki (12) and Dosha (11) while, the lowest was counted for Gora (6). There was not significant difference among genotypes for number of seeds per pod across location. Regarding number of pods per plant, Gora had the highest pods/plant in Chencha, Southern Ethiopia as reported by Zebire D, et al.

Thousand seed weight (g): Analysis of variance results revealed that there were significant differences ($P<0.01$) for thousand seed weight. The highest mean of thousand seed weight was recorded for variety Gora (754.44 g) whereas; the lowest seed weight was recorded for variety Degaga (506.67 g) (Table 4). Similar to this result much previous research findings reported by Mitiku, et al.

Grain yield (kg ha^{-1}): Combined analysis of variance revealed that Genotypes (G) and Locations (L) were significant on grain yield of ten faba bean varieties. The presence of significant variations among the genotypes indicates the differences in the inherent genetic potential of the genotypes that makes easy of selection, while differences among the locations showed the variability in yield potential suitability of the test locations for faba bean production. Varieties Wolki (3711.11 kg ha^{-1}), Gora (3616.67 kg ha^{-1}) and Didia (3608.89 kg ha^{-1}) were the top yielder across locations whereas; variety Moti (2418.89 kg ha^{-1}) had the lowest mean grain yield (Table 4). In agreement to this result, Mesfin T et al. were reported the highest grain yield was obtained for variety Gora and the lowest from variety Moti. In other hand, Zebrie and Kiya, 2018 was reported the highest grain yield for variety Gora. However, this result was unlike with variety Moti as their finding report.

No	Varieties	Traits						
		DTF (days)	DTM (days)	PH (cm)	NPPP	NSPP	TSW (g)	YLD (kg/ha)

1	Didia	44.44^{a}	111^{abc}	144.02^{abc}	9^{bc}	3^{ab}	638.89^{c}	3608.68^{a}
2	Gora	44.44^{a}	111.78^{ab}	136.69^{bcd}	6^{c}	3^{ab}	754.44^{a}	3616.67^{a}
3	Hachalu	44.33^{a}	111.78^{ab}	141.44^{ad}	8^{bc}	4^{a}	597.78^{cd}	3277.78^{ab}
4	Wolki	43.89^{ab}	112.44^{a}	150.91a	12^{a}	3^{ab}	511.11^{e}	3711.11^{a}
5	Chalew	43.67^{ab}	109.22^{cd}	145.53^{ab}	9^{bc}	3^{ab}	694.44^{b}	3012.22^{ab}
6	Dosha	43.67^{ab}	110.67^{abc}	138.4^{ad}	11^{ab}	3^{ab}	576.67^{d}	3185.56^{ab}
7	Degaga	42.33^{bc}	109.78^{bcd}	121.74^{e}	10^{b}	3^{ab}	506.67^{e}	3147.78^{ab}
8	Gebelcho	41.78^{cd}	108.78^{cd}	139.89^{ad}	9^{bc}	3^{ab}	683.33^{b}	3338.89^{ab}
9	Moti	40.22^{d}	109.44^{cd}	128.99^{de}	8^{bc}	3ab	575.56^{d}	2418.89^{b}
10	Tumsa	40.11^{d}	107.67^{d}	131.73^{cde}	10^{b}	3^{ab}	626.66^{c}	3065.56^{ab}
	Mean	42.89	110.26	137.93	9.2	3.1	616.56	3238.31
	CV%	4.3	2.24	10.31	22.47	19.36	7.39	22.08
	LSD at 5%	1.74	2.33	13.44	2.83	1.41	43.06	1043.16
	P value	**	**	**	*	ns	**	*

**;*Significant difference at p=0.01 and p=0.05 respectively. Ns: non significance difference; DTF: Days To Flowering; DTM: Days To Maturity, NPPP: Number of Pod Per Plant, NSPP: Number of Seed Per Pod; TSW: Thousand Seed Weight and YLD: Grain Yield; kg: kilogram; g: gram and cm: centimeter.

Table 4: Mean performance of 10 faba bean varieties for yield and yield attribute traits across locations.

Conclusion

In the present study, the performance of recently released faba bean varieties were evaluated for yield and yield attributed traits. The study has revealed that the tested faba bean varieties had a significant difference in across three districts. In general, among ten evaluated faba bean varieties nine of them had high grain yield. Additionally, variety Gora had highest thousand seeds weight. Finally, Varieties Wolki, Gora and Didia ranked in the top third of all varieties across three testing locations. Hence, these varieties can be adaptable to eastern highlands of Ethiopia and are recommended for pre-extension demonstration.

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