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Evaluation the performance of commercial faba bean (*Vicia faba* L.) varieties on some morpho-physiological and N-fixing Traits under Eastern Ethiopia

Million Fikreselassie

School of Plant Sciences, Haramaya University, P. O. Box 138, Dire Dawa, Ethiopia

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Abstract

Eight commercial faba bean varieties were evaluated under field and green-house condition in 2011 and 2012 respectively at Haramaya University to evaluate their performance for yield, yield components and incidence and severity of major disease. The experiment was laid out in RCBD with three replications. The mean squares of the genotypes were highly significant for days to maturity, stand count, reactions to rust, plant height, biomass yield and thousand seed weight implying that a wide range of variability has been obtained for the traits studied. The GCV ranged from 0.04% to 2606%, while the PCV varied between 0.4% and 2682.59% for the same characters. The estimated broad sense heritability ranged from 10.58 % to 98.72%. Genetic gains that could be expected from selecting the top 5% of the genotypes varied from 1.90% to 235.07%. Number of effective and non effective nodules per plant estimates high heritability and genetic advance. The first six PC accounted for more than 74% of the total variation. The first principal component which accounted for about 21% of the variability was due to Incidence of rust, number of pods and seeds per plant and stand count. The eight released faba bean varieties were grouped into three clusters and their differences were mainly attributed to the variation thousand seed weight and stand count. Seed yield had significant genotypic associations with plant height and number of pods per plant. In general, from this study *Gachena* adapted and suitable for production to the other part of the country where *Gebelcho, Obse, Tumsa*, and *Cs20DK* were recommended for production.

*Corresponding Author: Million Fikreselassie ✉ million_fikresilassie@yahoo.com/millionf@haramaya.edu.et

Introduction

Faba bean (*Vicia faba* L.) is one of the major pulse crops occupying about 35 percent both in terms of area coverage and volume of annual production of all pulses produced in the country and grown in the highlands (1800-3000 meter above sea level) of Ethiopia (Gemechu *et al,* 2003). Ethiopia is now considered as one of the centers of secondary diversity for faba bean (Yohannes, 2000).

The inception of well organized faba bean breeding in Ethiopia was dated three decades back with the strong hybridization program commenced in mid 1980'. The main objective was to improve the productivity of the crop through the development of varieties tolerant/resistant to different constraints and suitable for cultivation under different agro ecologies of the country (Asfaw et al 1994). Its improvement, breeding, is based on variability available in the local collection of indigenous landraces and hybridization made with exotic germplasm introduced mostly from ICARDA (Gemechu *et al,* 2003).

This crop has manifold advantages in the economic lives of the farming community in the high lands of the country. It is a source of food, fed, cash to farmers. Also play significant role in soil fertility practices. However, its share in the countries pulse export is small (Newton *et al.,* 2011, Amanuel *et al.*, 1993, Tanner *et al.,* 1991). Although the absolute figure is still small compared to the potential, Ethiopia's export of faba beans has shown an increase since the year 2000. Major market destinations for Ethiopian faba beans are Sudan, South Africa, Djibouti, Yemen, Russia and USA.

It is evident from the report of entral statistical authority (CSA, 2011), faba beans were planted to 3.88 % (about 459,183.51 hectares), of the grain crop area. The production obtained from faba beans, 3.43 % (about 6,977,983.87 quintals) of the grain production

The National Agricultural Research System (NARS) has developed and registered different improved faba bean suitable for national and regionally which are found to give yields ranging from 2.5 - 6 tone/ha on research fields and 1.8 - 4 ton/ha on farmers fields. As a result a number of improved varieties were developed and released to farmer. Therefore, the objective of this piece of paper is to present and discuss on the performance of released faba bean varieties to in terms of yield, yield components and incidence and severity of major disease

Material and methods

Seven nationally released faba bean varieties developed by Holetta Agricultural Research Center along with a regionally released variety, *Gachena* ,from Haramaya university were considered in this study. Gachena (EH91001-13-2) was released by Haramaya University after fulfilling the requirements set by the National Variety Release committee for production in Eastern highlands of the country, primarily in areas with average annual rain fall of 700 to 1000 mm. It is typically characterized by average seed yield of 17 to 30 q/ha and 11 to 28q/ha on research and farmer fields, respectively (Million and Habtamu, 2012).

The materials were tested under both field and green house condition in 2011 and 2012 respectively.

Field experiment

The field experiment was conducted at Haramaya University Research field located at 9°24'N and 42°03'E, in Ethiopia during 2011 main cropping season. Haramaya has an altitude of 1980 meter above sea level. It was in semi-arid sub-tropical belt of eastern Ethiopia. The area receives an average annual rainfall of 870 mm. The soil is characterized as a fluvisol with a pH of 7.4 (Solomon, 2006).

Treatments were arranged in RCBD with three replications. Seeding was done in a plot of 5m X 4m with regular spacing of 10 cm between plants and 40 cm between rows. The layout and randomization were as per the standard procedure set by Cochran and Cox (1957).

the following data were collected during 2011 from the whole plot or from ten sample plants randomly from each plot. Mean values of these samples were utilized to estimate the performance of each treatment for the traits under consideration. the following data such as; days to 50%flowering, days to 90% physiological maturity, grain filling period, stand count, chocolate spot, rust incidence, lodging, plant height, number of pods per plant, number of seeds per plant, number of seeds per pod, biomass yield per plot, thousand seed weight, seed yield per lot and per hectare.

Green house experiment

The same treatment was conducted under the green house condition in 2012. Two seeds per hole were placed carefully to ensure the first germination. Thinning was made after germination. Treatments were arranged in RCBD with three replications. Five plants per pot were maintained and the following data were collected based on single plant bases. germination day, dry matter content, days to 50% flowering, leaf number, plant height at 50% of flowering, number of tiller, number of effective nodule, number of non effective nodules, dry weight of effective nodules, dry weight of non effective nodules

The data were subjected to the analyses of variance (ANOVA) for randomized complete block design was performed using the SAS program software (SAS, 1996). The coefficients of variations at phenotypic and genotypic levels were estimated using the formula adopted by Johnson *et al.* (1955). Broad-sense heritability (h^2) for traits were estimated using the formula adopted by Allard (1960). Squared distance (D^2) for each pair of cluster combinations was computed using the formula adopted by Singh and Chaudhary (1999) and Phenotypic and genotypic correlation coefficients were estimated using the standard procedure suggested by Miller *et al.* (1958).

Results and discussion

Analysis of variance

The analysis of variance from the field experiment (Table 1) showed that the mean squares due to replication were highly significant for stand count and biomass yield, significant for number of pods per plant, seed yield per plot and per hectare indicated differences between the three replications (environment) and these are significant enough to see the genetic performance of the commercial varieties. It is evident from the results, mean squares due to genotypes were highly significant for days to maturity, stand count, reactions to the disease rust, plant height, biomass yield and thousand seed weight, and significant for number of seeds and pods per plant indicating the existence of sufficient variability among the released varieties regarding with these traits.

From the green house experiment (Table 2), the analysis of variance showed that the mean squares due to replication were not significant in all the traits under consideration, indicated homogenous environment. Mean squares due to genotypes showed highly significant for germination day and dry matter significant for number and dry weight of non effective nodules per plant. Here under green house condition High efficiency of completely randomized design over randomized completely block design was noticed for all traits.

The evaluated released faba bean varieties in this study showed significant phenotypic variability in terms of plant morphology, phenology and yield attributes. These results are similar with the findings of other scholars like Gemechu et al., 2005.

Range of parameters

It depicted from Table 3, the variety *Tumsa* showed shorter days to maturity (137 days) indicated that it may be suitable to lower rainfall regions whereas the late types, obse and Cs20DK with 145 and 146 days respectively, can be adapted to the highland areas with dependable rainfall. This variability showed suitable varieties for the various agro-ecological zones of the country. The existence of variability in seed size is associated with seedling vigour, emergence of seed and stress tolerance (McCormic, 2004). Larger seeds have greater cotyledon reserves and therefore can provide energy to young seedlings at faster rate (Qui *et al.,* 1994). Among the tested varieties *Gebelcho* and *Moti* had high thousand seed size as a result they have a potential to escape/ survive in drought environment since they had large storage food in their endosperm as compared with the rest tested varieties. Whereas, *Degaga* yielded the smallest seed size (508.80g) but exhibited high number of seeds per plant. Generally, the broad spectrum of variability observed among the released varieties for different characters indicates possibilities for adaptation to different agro-ecological condition. It was generally noted that all varieties had exhibited some degree of nodulation, with a mean score of 43.79 effective and 26.75 non effective nodules per plant.

Table 1. Analysis of variance for 15 traits of faba bean varieties tested under field condition in 2011.

Variables	MSR(2) $^{\beta}$	MSG(7)	MSE	CV (%)
DF	1.50 ^{ns}	12.54 ^{ns}	3.37	5.56
DM	6.00 ^{ns}	31.6**	3.53	2.51
GFP	9.50 ^{ns}	28.36 ^{ns}	4.93	6.07
STD	477.04**	334.94**	4.51	6.05
CHSP	0.67 ^{ns}	1.31 ^{ns}	0.82	22.78
RUST	0.04 ^{ns}	3.59**	0.78	21.85
LODG	0.01 ^{ns}	0.18 ^{ns}	0.31	27.43
PH	18.37 ^{ns}	99.88**	3.57	2.73
PPPL	8.40*	4.95*	1.34	17.30
SPP	0.01 ^{ns}	0.06 ^{ns}	0.24	8.78
SPPL	54.00 ^{ns}	47.12*	4.13	19.30
BMY	16.00**	12.26**	1.40	8.32
TSW	54.00 ^{ns}	57856.82**	64.86	9.46
SYLDP	9.28*	1.82 ^{ns}	1.34	22.62
SYPH	2312604*	454389 ^{ns}	670.63	22.62

Table 2. Analysis of variance for 10 traits of faba bean varieties tested under greenhouse condition in 2012.

Variables	MSR(2) $^{\beta}$	MSG(7)	MSE	CV (%)
Gerday	0.98^{ns}	15.61^{**}	0.68	2.85
Drymt	1.88^{ns}	20.95^{**}	1.87	11.61
DF	4.04^{ns}	32.00^{ns}	3.54	7.27
LFN	5.79^{ns}	15.07^{ns}	4.20	9.61
PhF	16.25^{ns}	42.71^{ns}	5.95	10.15
NTILL	0.29^{ns}	5.31^{ns}	1.69	22.31
NENOD	$618.\ 79^{ns}$	1856.23^{ns}	31.90	66.87
NNENOD	12.54^{ns}	429.52^{*}	10.39	72.49
DwtENW	0.14^{ns}	0.11^{ns}	0.27	86.66
DwtNEN	0.05^{ns}	0.08^{*}	0.14	65.61

*, ** Significant at 0.05 and 0.01 probability level respectively and ^{ns} non significant

MSR= Mean Square due to replication, MSG= Mean Square due to genotypes, MSE= Mean Square due to error, CV%= Coefficient of variation in percentage.

$^{\beta}$ Figures in parenthesis indicate degrees of freedom.

Gerday= germination day, Drymt= Dry matter, DF= Days to 50% flowering, LFN=Leaf number, PhF= Plant height at 50% of flowering, NTILL= Number of tiller, NENOD=Number of effective nodule, NNENOD= Number of non effective nodules, DwtENW= Dry weight of effective nodules, DwtNEN= Dry weight of non effective nodules.

Estimation of genotypic and phenotypic variations

High genotypic coefficient of variation was observed for thousand seed weight (2606.90%), followed by number of effective (400.83%) and non effective(369.05%) nodules per plant, Stand count(140.67%),number of seed per plant (46.70%) (Table 3). However, low for numbe of seeds per pod (0.04%) and temporal data, such as number of days to flower (0.648%). The estimated values of phenotypic variances were in the range of 0.01 for number of seeds per plant to 18402.20 for thousand seed weight. This finding is in contrast with Fikreselassie *et al* (2012) who reported high phenotypic variance in fenugreek for number of seeds per plant in fenugreek. The lowest and highest genotypic variances were found for the same traits respectively.

Estimation of heritability in broad sense

Estimates of heritability in broad sense under the field and green house condition are presented hereunder. Under the field, it were high for plant height (97.64%), thousand seed weight (97.18%), resistance to rust (93.42%), number of days to maturity (88.74%) and flower (76.05%). In line with the field, under the green house condition, high heritability was estimated for all of the traits under consideration except leaf number per plant (Table 3). These characters, therefore, may respond effectively to phenotypic selection. However, low values of heritability were estimated for number of seeds per pod (10.58%), indicating limited possibility of improvement for this character through selection. In earlier studies, high heritability estimates for seed weight (Shukla and Sharma, 1978) were reported. This finding is thus in agreement with the results obtained in the present investigation.

Generally, heritability determines the effectiveness of selection. The effectiveness of selection for a trait depends on the relative importance of the genetic and environmental factors in the expression of phenotypic differences among genotypes in a population (Singh,1990). The components of yield that were most heritable in this faba bean population were plant height, thousand seed weight and dry matter. Therefore, the simultaneous selection for these traits could lead to an increase in seed yield.

Table 3. Estimates of minimum, mean and maximum value, variance and coefficient of variation at phenotypic (σ^2p), genotypic (σ^2g) level, heritability in broad sense ($h^2\%$), genetic advance in absolute (GA) and percent of mean (GAM) for 25 traits of Faba bean.

Variables	Min	Mean	Max	σ^2p	σ^2g	GCV%	PCV%	$h^2\%$	GA	GAM
Under Field										
DF	56.67	59.75	62.67	0.50	0.38	0.64	0.84	76.05	5.29	8.85
DM	137.33	141.00	146.00	7.19	6.38	4.53	5.10	88.74	6.46	4.58
GFP	78.00	81.25	86.67	2.18	1.33	1.64	2.68	61.00	6.20	7.63
STD	57.00	74.54	86.33	161.94	104.86	140.67	217.25	64.75	6.02	8.08
CHSP	3.00	3.58	4.33	0.28	0.21	5.98	7.93	75.38	1.28	35.58
RUST	2.33	3.58	5.00	1.06	0.99	27.74	29.69	93.42	1.50	41.95
LODG	1.00	1.13	1.67	0.04	0.03	2.65	3.53	74.85	0.48	42.55
PH	119.00	130.75	137.00	29.74	29.04	22.21	22.75	97.64	7.19	5.50
PPPL	6.00	7.73	10.13	1.88	1.05	13.61	24.28	56.04	1.55	20.03
SPP	2.49	2.76	2.98	0.01	0.00	0.04	0.40	10.58	0.05	1.90
SPPL	16.87	21.43	27.60	14.62	10.01	46.70	68.23	68.44	5.83	27.22
BMY	13.87	16.88	19.67	5.18	3.43	20.31	30.70	66.15	1.91	11.32
TSW	508.80	685.99	852.03	18402.2	17883.2	2606.9	2682.6	97.18	130.03	18.96
SYLDP										
SYLDH										
Under Green house										
Geday	19.33	23.77	25.33	5.12	5.05	21.24	21.51	98.72	1.38	5.83
Drymt	13.50	16.07	20.00	6.02	5.82	36.23	37.47	96.68	3.73	23.21
DFg	41.33	48.67	50.67	7.55	6.49	13.34	15.52	85.97	6.28	12.90
LFN	41.00	43.69	47.60	2.33	0.85	1.95	5.33	36.50	3.16	7.24
PhF	50.40	58.64	63.87	4.83	2.44	4.16	8.24	50.40	6.19	10.55
NTILL	6.00	7.58	10.33	1.14	0.82	10.75	14.99	71.73	2.50	32.98
NENOD	1.67	43.79	80.67	325.79	175.53	400.83	743.96	53.88	35.46	80.97
NNENOD	8.67	26.75	47.67	104.37	98.72	369.05	390.16	94.59	20.27	75.79
DwtENW	0.03	0.21	0.35	0.022	0.020	1.13	1.26	89.85	0.50	235.07
DwtNEN	0.04	0.24	0.62	0.02	0.02	9.23	9.96	92.69	0.27	110.39

DF= Days to 50% flowering, DM= Days to 90% maturity, GFP= grain filling period, CHSP= chocolate spot, RUST= rust, LODG= logging, PH= plant height, PPPL= number of pods per plant, SPP= number of seeds per pod, SPPL= number of seeds per plant, BMY= biomass per plot, TSW= thousand seeds weight, SYLDP= seed yield per plot, SYLDH= seed yield per hectare, Gerday= germination day, Drymt= Dry matter, DFg= Days to 50% flowering in green house, LFN=Leaf number, PhF= Plant height at 50% of flowering, NTILL= Number of tiller, NENOD=Number of effective nodule, NNENOD= Number of non effective nodules, DwtENW= Dry weight of effective nodules, DwtNEN= Dry weight of non effective nodules.

Table 4. The eigen values and vectors of the correlation matrix for 22 traits of released faba bean varieties.

Parameter	PRIN1	PRIN2	PRIN3	PRIN4	PRIN5	PRIN6
Eigen value	5.083	3.486	2.835	2.637	2.136	1.697
% variance	21.18	14.53	11.81	10.99	8.90	7.07
Cumulative	21.18	35.70	47.52	58.50	67.40	74.47
Character						
DF	0.108	0.197	0.032	-0.135	-0.242	0.178
DM	-0.080	-0.176	0.031	0.431	-0.184	0.298
STD	0.278	-0.040	0.307	0.019	0.171	0.182
ChSp	-0.208	-0.069	0.025	0.419	-0.115	0.226
Rust	0.312	0.072	-0.100	0.071	0.204	-0.152
Lodg	0.180	0.001	-0.339	0.159	-0.286	0.256
PH	0.176	0.061	0.032	0.079	0.126	-0.040
PPPl	0.288	0.156	-0.192	0.133	0.043	0.326
Spp	0.061	0.170	-0.067	-0.275	0.306	0.288
SPPl	0.285	0.212	-0.185	0.036	0.158	0.369
Biom	-0.097	0.276	0.344	0.184	0.081	-0.009
TSW	-0.180	0.308	-0.187	-0.007	0.203	-0.242
Syldp	-0.179	0.254	0.398	0.046	0.077	0.196
Syldh	-0.179	0.254	0.398	0.046	0.077	0.196
Gerday	0.255	-0.304	0.224	0.074	0.198	-0.040
Drymt	-0.330	0.128	-0.215	0.054	0.145	0.014
LFN	-0.159	0.143	-0.100	-0.355	0.063	0.271
NTILL	-0.050	-0.243	-0.054	-0.184	0.363	0.208
NENOD	-0.229	-0.230	-0.142	0.179	0.275	0.199
NNENOD	0.175	0.266	0.001	0.311	0.004	-0.135
DwtEN	-0.202	-0.235	-0.111	0.202	0.353	0.008
DwtNEN	0.222	0.200	-0.039	0.275	0.268	-0.249

PRIN1, PRIN2, PRIN3, PRIN4 and PRIN5 = Principal component 1, 2, 3, 4 and 5 respectively, DF= Days to 50% flowering, DM= Days to 90% maturity, GFP= grain filling period, CHSP= chocolate spot, RUST= rust, LODG= logging, PH= plant height, PPPL= number of pods per plant, SPP= number of seeds per pod, SPPL= number of seeds per plant, BMY= biomass per plot, TSW= thousand seeds weight, SYLDP= seed yield per plot, SYLDH= seed yield per hectare, Gerday= germination day, Drymt= Dry matter, LFN=Leaf number, NTILL= Number of tiller, NENOD=Number of effective nodule, NNENOD= Number of non effective nodules, DwtENW= Dry weight of effective nodules, DwtNEN= Dry weight of non effective nodules.

Table 5. Mean, range, SD and CV% of genetic divergence in phonological and morphological traits of the three clusters of faba bean.

	Cluster														
	I					II					III				
Character	Min	Mn	Max	SD	CV%	Min	Mn	Max	SD	CV%	Min	Mn	Max	SD	CV%
DF	58.00	60.27	62.67	3.91	8.06	56.67	59.00	61.33	3.56	7.41	-	58.67	-	-	-
DM	137.33	141.60	146.00	1.32	0.93	138.00	140.00	142.00	2.00	2.82	-	140.00	-	-	-
GFP	78.00	81.33	86.67	4.37	23.48	80.67	81.00	81.33	0.33	0.13	-	81.33	-	-	-
STD	57.00	74.33	83.33	3.67	4.93	72.00	79.17	86.33	2.86	3.61	-	66.33	-	-	-
ChSp	3.00	3.80	4.33	0.63	16.64	3.00	3.00	3.00	0.00	0.00	-	3.67	-	-	-
Rust	2.33	3.40	5.00	0.82	24.01	4.33	4.67	5.00	0.82	17.49	-	2.33	-	-	-
Lodg	1.00	1.00	1.00	0.00	0.00	1.00	1.34	1.67	0.41	30.61	-	1.33	-	-	-
PH	131.00	133.93	137.00	5.70	9.74	119.00	122.67	126.33	5.87	10.03	-	131.00	-	-	-
PPPl	6.00	7.05	8.13	1.30	18.41	8.60	9.37	10.13	1.79	19.17	-	7.87	-	-	-
Spp	2.49	2.70	2.81	0.22	8.33	2.80	2.89	2.98	0.40	13.97	-	2.85	-	-	-
SPPl	16.87	19.13	23.47	4.92	25.72	25.73	26.67	27.60	1.63	6.12	-	22.40	-	-	-
BMY	16.73	18.13	19.67	0.94	5.16	13.87	14.44	15.00	2.86	19.80	-	15.53	-	-	-
TSW	526.97	685.25	852.03	16.51	2.41	508.80	618.64	728.47	74.18	11.99	-	824.37	-	-	-
SYLDP	6.00	6.19	6.47	0.66	10.59	4.67	4.77	4.87	3.18	66.80	-	6.93	-	-	-
SYLPH	3000.0	3096.7	3233.3	328.1	10.59	2333.3	2383.3	2433.3	1592.2	66.80	-	3466.7	-	-	-
Geday	21.00	24.12	25.20	0.52	2.17	24.93	25.13	25.33	0.28	1.13	-	19.33	-	-	-
Drywt	13.70	15.95	18.80	2.15	13.50	13.50	14.42	15.33	1.34	9.27	-	20.00	-	-	-
LFN	41.00	42.91	45.93	3.45	8.05	43.60	43.70	43.80	6.79	16.53	-	47.60	-	-	-
NTILL	6.00	7.33	8.33	1.70	23.22	7.00	8.67	10.33	1.78	20.53	-	6.67	-	-	-
NEND	1.67	44.87	80.67	40.07	81.01	28.67	45.67	62.67	20.41	42.38	-	34.67	-	-	-
NNEND	8.67	27.67	47.67	11.14	72.02	29.33	30.50	31.67	8.29	73.11	-	14.67	-	-	-
DWtEN	0.03	0.20	0.35	0.33	98.69	0.14	0.22	0.29	0.11	36.49	-	0.27	-	-	-
DwtNEN	0.04	0.26	0.62	0.15	69.31	0.25	0.27	0.30	0.18	75.11	-	0.10	-	-	-

Min, Mn and Max stands for minimum, mean and maximum value, SD= standard deviation, CV%= Coefficient of variance, DF= Days to 50% flowering, DM= Days to 90% maturity, GFP= grain filling period, CHSP= chocolate spot, RUST= rust, LODG= logging, PH= plant height, PPPL= number of pods per plant, SPP= number of seeds per pod, SPPL= number of seeds per plant, BMY= biomass per plot, TSW= thousand seeds weight, SYLDP= seed yield per plot, SYLDH= seed yield per hectare, Gerday= germination day, Drymt= Dry matter, LFN=Leaf number, NTILL= Number of tiller, NENOD=Number of effective nodule, NNENOD= Number of non effective nodules, DwtENW= Dry weight of effective nodules, DwtNEN= Dry weight of non effective nodules

Table 6. Pair wise generalized squared distance (D^2) among 3 clusters constructed from 8 released faba bean varieties.

Cluster	Cluster one	Cluster two	Cluster three
Cluster one	0.940	8910**	4606**
Cluster two		2.772	9560**
Cluster three			0.00

**, significant at 1%

Table 7. Estimates of correlation coefficients at phenotypic (above diagonal) and genotypic (below diagonal) levels of some 20 traits in Faba bean varieties.

Traits	DF	DM	GFP	STD	CHSP	RUST	LODG	PH	PPPL	SPP
DF	1.00	0.181	-0.522**	-0.049	0.163	0.081	0.341	0.055	0.349	-0.183
DM	0.397	1.00	0.744**	0.002	0.823**	-0.255	0.275	0.291	-0.032	-0.264
GFP	-0.246	0.792*	1.00	0.036	0.603**	-0.277	0.007	0.215	-0.265	-0.104
STD	-0.435	-0.251	0.024	1.00	-0.126	0.323	-0.130	-0.213	0.345	0.131
CHSP	0.405	0.755*	0.527	-0.566	1.00	-0.315	0.035	0.412*	-0.150	-0.318
RUST	-0.549	-0.473	-0.134	0.364	-0.625	1.00	0.239	-0.458*	0.505*	0.235
LODG	0.196	0.059	-0.068	-0.242	-0.315	0.044	1.00	-0.311	0.592**	-0.045
PH	0.392	0.324	0.081	-0.535	0.577	-0.431	-0.286	1.00	-0.341	-0.183
PPPL	-0.118	-0.140	-0.069	0.101	-0.449	0.510	0.737*	-0.619	1.00	0.111
SPP	-0.666	-0.758*	-0.357	0.201	-0.758*	0.581	0.218	-0.592	0.327	1.00
SPPL	-0.355	-0.373	-0.158	0.180	-0.615	0.650	0.646	-0.702*	0.954*	0.582
BMY	0.279	0.093	-0.088	-0.312	0.420	-0.088	-0.486	0.868**	-0.484	-0.537
TSW	-0.331	-0.405	-0.207	-0.484	0.199	0.081	-0.299	0.248	-0.139	0.265
SYLDP	-0.053	0.014	0.050	-0.259	0.376	-0.537	-0.375	0.734*	0.654*	-0.270
SYLDH	-0.053	0.014	0.050	-0.259	0.376	-0.537	-0.375	0.734*	0.654*	-0.270
Drywt	-0.068	0.195		-0.765*	0.624	-0.428	-0.088	0.384	-0.311	-0.028
NENOD	0.304	0.450		-0.556	0.626	-0.297	-0.189	0.124	-0.346	-0.191
NNENOD	-0.180	-0.083		0.123	-0.125	0.344	0.112	0.231	0.384	-0.163
DwtEN	-0.026	0.694*		-0.330	0.724*	-0.249	-0.272	0.127	-0.330	-0.289
DwtNEN	-0.405	-0.280		0.298	-0.308	0.687	-0.016	-0.066	0.491	0.099

*, ** Significant at 0.05 and 0.01 probability level respectively

DF= Days to 50% flowering, DM= Days to 90% maturity, GFP= grain filling period, CHSP= chocolate spot, RUST= rust, LODG= logging, PH= plant height, PPPL= number of pods per plant, SPP= number of seeds per pod, SPPL= number of seeds per plant, BMY= biomass per plot, TSW= thousand seeds weight, SYLDP= seed yield per plot, SYLDH= seed yield per hectare, Gerday= germination day, Drymt= Dry matter, LFN=Leaf number, NTILL= Number of tiller, NENOD=Number of effective nodule, NNENOD= Number of non effective nodules, DwtENW= Dry weight of effective nodules, DwtNEN= Dry weight of non effective nodules

Table 7 continue

Traits	SPPL	BMY	TSW	SYLDP	SYLDH	Drywt	NENOD	NNENOD	DwtEN	DwtNEN
DF	0.222	0.195	-0.157	-0.152	-0.152	-0.031	-0.037	0.099	-0.176	-0.010
DM	-0.136	0.020	-0.325	0.030	0.030	0.058	0.328	0.114	0.0303	-0.127
GFP	-0.269	-0.116	-0.175	0.129	0.129					
STD	0.377	0.020	-0.298	0.126	0.126	-0.592**	0.283	0.193	-0.179	0.285
CHSP	-0.248	0.209	0.102	0.197	0.197	0.271	0.492*	0.071	0.324	-0.158
RUST	0.561**	-0.045	0.036	-0.302	-0.302	-0.317	-0.266	0.319	-0.279	0.509*
LODG	0.496*	-0.392	-0.312	-0.410*	-0.410*	-0.123	-0.095	0.192	-0.207	0.082
PH	-0.369	0.646**	0.288	0.408*	0.408*	0.263	0.135	0.206	0.142	-0.024
PPPL	0.941**	-0.049	-0.091	-0.187	-0.187	-0.259	-0.151	0.338	-0.228	0.412*
SPP	0.435*	-0.059	0.120	0.099	0.099	0.091	-0.057	0.053	-0.182	0.035
SPPL	1.00	-0.039	-0.014	-0.117	-0.117	-0.205	-0.176	0.350	-0.276	0.418*
BMY	-0.536	1.00	0.200	0.710**	0.710**	0.108	-0.035	0.284	-0.109	0.196
TSW	0.005	0.351	1.00	0.129	0.129	0.555**	0.057	0.163	0.103	0.223
SYLDP	-0.614	0.573	0.456	1.00	1**	0.234	-0.040	0.015	-0.065	-0.092
SYLDH	-0.614	0.573	0.456	1.00**	1.00	0.234	-0.040	0.015	-0.065	-0.092
Drywt	-0.279	0.142	0.706*	0.509	0.509	1.00	0.433*	-0.197	0.461*	-0.201
NENOD	-0.396	-0.049	0.110	-0.163	-0.162	0.541	1.00	-0.300	0.737**	-0.196
NNENOD	0.342	0.462	0.178	0.220	0.220	-0.211	-0.726*	1.00	-0.229	0.757**
DwtEN	-0.385	-0.056	0.047	-0.028	-0.028	0.547	0.827*	-0.469	1.00	0.031
DwtNEN	0.524	0.311	0.235	-0.073	-0.073	-0.325	-0.646	0.894**	-0.420	1.00

*, ** Significant at 0.05 and 0.01 probability level respectively

DF= Days to 50% flowering, DM= Days to 90% maturity, GFP= grain filling period, CHSP= chocolate spot, RUST= rust, LODG= logging, PH= plant height, PPPL= number of pods per plant, SPP= number of seeds per pod, SPPL= number of seeds per plant, BMY= biomass per plot, TSW= thousand seeds weight, SYLDP= seed yield per plot, SYLDH= seed yield per hectare, Gerday= germination day, Drymt= Dry matter, LFN=Leaf number, NTILL= Number of tiller, NENOD=Number of effective nodule, NNENOD= Number of non effective nodules, DwtENW= Dry weight of effective nodules, DwtNEN= Dry weight of non effective nodules

Estimation of expected genetic advance

Genetic gains that expected from selecting the top 5% of the genotypes, as a percent of the mean, varied from 1.90% for number of seeds per pod to 42.55% for the trait lodging percentage in the field and 5.83% for germination date to 235.07% for dry weight of effective nodules per plant in the green house, indicating an increase of 1.90% to 42.55% and 5.83% to 235.07% the same magnitude respectively can be made by selection based on these traits under similar conditions to this study. The low values of expected genetic advance for the traits like number of seed per pod and number of days to flowering are due to low variability for the traits indicated by the low genotypic and phenotypic coefficient of variation values (Table 3). This indicates the importance of genetic variability in improvement through selection. Plant height, thousand seed weight, rust resistance and number of days for maturity under the field condition and number of effective and non effective nodules per plant under the green house condition estimates high heritability and genetic advance as compared to other yield contributing traits. This suggests that they may serve as important traits in indirect selection for higher seed yield. As observed in the present investigation, the low expected genetic advance for number of seeds per pod was due to low variability for the traits.

Principal component analysis

In order to assess the pattern of variations, principal component analysis was done by considering the twenty two variables simultaneously. Six of the twenty-two principal components accounted for more than 74% of the total variation in the released faba bean varieties (Table 4). The first principal component accounted for 21.18% of the total variation. While eleven of the twenty-two traits considered exerted positive effects on this component and the rest of the traits exerted negative effects of different magnitudes. Among those traits having positive and greater influence include: Incidence of rust, number of pods and seeds per plant, stand count, germination day, dry weight of non effective nodules per in same order.

Conversely, dry matter, number of effective per plant, reaction to chocolate spot, dry weight of effective nodules per plant, thousand seed weight, seed yield per plant and per hectare, leaf number per plant and days to mature exerted negative influence. The second component accounting for an additional 14.53% of the total variation primarily illustrates the patterns of variations in thousand seed weight, biomass yield per plot, seed yield per plant and per hectare which were found to have positive impacts on the second component but had negative impact on the first component. Germination day, number of tiller per plant, dry weight of effective nodules per plant, number of effective nodules per plant and days to maturity had negative impact on it. The third principal component accounted for 11.81% of the total variation and the seed yield per plant and per hectare and most of the yield contributing traits was exhibiting positive effects. The traits days to maturity and resistance to chocolate spot exerted maximum and positive effect on the fourth component. Whereas, the traits number of tiller per plant, dry weight of effective nodules and number of seeds per plant exerted high positive influence on the fifth principal component. It is revealed from the result number of seeds and pods per plant exert their maximum positive components on the sixth component. The traits that contributed most for the first principal component were phenotypically negatively associated with the major traits of the second principal component (Table 7). This indicates there is variability among the traits of the improved faba bean varieties considered in this investigation.

Clustering of varieties and divergence analysis

Genetic diversity plays an important role in plant breeding because hybrids between lines of diverse origin generally display a greater heterosis than those between closely related strains. The average linkage technique of clustering produced a more understandable portrayal of the eight faba bean varieties by grouping them into three clusters, whereby different members within a cluster being assumed to be more closely related in terms of the trait under consideration with each other than those members in different clusters. Similarly, members in clusters with non-significant distance were assumed to have more close relationship with each other than they are with those in significantly distant clusters. Table 5 indicates the range (minimum and maximum), mean, standard deviation and CV% of genetic divergence in phonological and morphological traits of the three clusters and detail account of the characteristics of each cluster is presented hereunder.

Cluster I: consisted of five varieties (*Gebelcho, Obse, Tumsa, Cs20DK and Gachena*). Members in this cluster laid on requiring long period for flowering and maturity (late), high biomass yield, tall in height and high infestation by chocolate spot. Intermediate value with stand count, rust infestation, thousand seed weight and seed yield. Here, all the data undergoing in green house exhibited in the intermediate manner. However, low for yield contributing traits like number of pods per plant, seed per pod and per plant and exhibited resistance for lodging. So the varieties under this cluster are suitable for highlands with relative high rain fall areas.

Cluster II: consisted of two varieties (*Degagga and Dosha*), which were characterized by low in seed yield, biomass yield, thousand seed weight, dry matter, number of leaves per plant, and dry weight of effective nodules per plant. It also exhibited shorter in height and low infestation by chocolate spot (resistance). These materials in this cluster also exhibited high stand count, late in germination day, high number of tiller per plant, number of total (effective and non effective) nodules per plant, dry weight of non effective nodules per plant, susceptible to rust, lodging and other yield components like number of pods per plant, seed per pod and per plant. Therefore *Degagga and Dosha* are becoming suitable for gene source for developing the variety which resists the disease chocolate spot.

***Cluster III*:** Consisted of one variety (*Moti*) and it was found to be the most superior variety interms of seed size, seed yield, dry matter content, number of leaves per plant and dry weight of non effective nodules per plant. It also exhibited resistance in rust infestation and earlier in days to flowering and germination day. However, low in stand count, number of tiller per plant, number of total nodules per plant and dry weight of non effective nodules per plant. It yielded intermediate in the rest of the traits under studied. *Moti* can be used as a source for gene resistance the disease rust.

In general, the differences between the clusters were mainly attributed to the variation in thousand seed weight and stand count. Other traits such as days to flowering, reaction to chocolate, plant height have contributed equally well for cluster constellations. These traits were also the major contributors to the principal one and two (Table 4).

The maximum distance was found between cluster two and three (D^2=9560) (Table 6). Cluster two constitutes two varieties *Degagga* and *Dosha*, while cluster three constitutes a single variety *Moti*. The second divergent clusters was cluster one and two (D^2= 8910). Cluster one constitutes five released varieties (*Gebelcho, Obse, Tumsa, Cs20DK and Gachena). Gachena* was released from Haramaya University for Eastern part of the country. From this study *Gachena* also deserves and adapt well to the other part of the country where *Gebelcho, Obse, Tumsa,* and *Cs20DK* were recommended for production.

Generally, maximum genetic segregation and genetic recombination is expected from crosses that involve parents from the clusters characterized by significant distances (Gemechu *et al.,* 1997). In the present investigation, therefore, crossing of the varieties *Degagga* and *Dosha* with *Moti* will give rise to maximum genetic segregation. Among the three clusters formed, cluster two showed the maximum intra-cluster D^2 value of 2.772. Since cluster three contains sole variety, the intra-cluster D^2 value is zero (Table 6). The result revealed that even though cluster one contains the largest number of varieties (five varieties), it had the shortest intra-cluster distance. This indicates that the varieties grouped in this cluster are more similar as compared with the varieties in the second clusters. In a similar fashion, there were only two accessions for cluster two, but it was more divergent as compared with the varieties present in the rest of the clusters.

Analysis of correlation coefficient

The existence of strong positive correlation between seed yield and different traits helps in identifying traits that could be used for indirect selection of higher yielding cultivars (Steel and Torrie, 1984). Yield is a complex trait, which is controlled by many genes (polygenic) and usually has low heritability (Akinwale *et al*., 2011). Hence, simple traits that have high genetic correlation with seed yield and high heritability could be used for indirect selection for seed yield. Table 7 summarizes genotypic and phenotypic correlation coefficients between all possible pairs of the twenty traits recorded from the eight released faba bean varieties.

Seed yield had positive and significant genotypic correlations with plant height (r=0.734), number of pods per plant (r=0.654). It also had positive and highly significant phenotypic correlations with biomass yield and significantly with plant height. However, seed yield negative and significant phenotypic correlations with rust incidence. The positive significant correlation observed between seed yield and plant height indicates that tall plants supporting many leaves could increase total biomass production through increase carbon fixation that can ultimately be partitioned to reproductive organ. Pods per plant exhibited a positive association with seed yield per plant. This is an indication that plants bearing more number of pods per plant produce more seed yield. Thus, selection for pods number alone will bring about a definite improvement in seed yield.

Dry matter content had negative significant genetic correlation with stand count and positive with thousand seed weight. It also had positive phenotypic correlation with dry weight of effective nodules implied the interdependence of the traits. There was positive genotypic correlation between dry weight of effective nodules with the disease chocolate spot. Here, as number of effective nodules increase the plant susceptible to disease chocolate spot.

In this particular investigation, in most of cases phenotypic and genotypic correlations closely agreed. The close agreement of phenotypic and genotypic correlations may be due to the reduced environmental variance (Hailu, 1988). Thus, the phenotypic correlation coefficient reflects more or less the real association among the character considered.

The positive associations between characters imply the possibility of correlated response to selection and it follows that with the increase in one, will entail an increase in another and the negative correlation preclude the simultaneous improvement of those traits along with each other.

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References

Akinwale MG, Gregorio F, Nwilene F, Akinyele BO, Ogunbayo SA, Odiyi AC. 2011. Heritability and correlation coefficient analysis for yield and its components in rice (*Oryza sativa* L.). African Journal of Plant sciences **5**, 207-212.

Allard RW. 1960. Principles of Plant Breeding. John Willey and sons, Inc. New York.

Amanuel Gorfu, Tanner DG, Assefa Taa, Duga Debele. 1993. Observation on wheat and barley-based cropping sequences trials conducted for eight years in South-eastern Ethiopia. Paper presented at the 8th Regional Workshop for Eastern, Central and Southern Africa, 7-20 June 1993, Kampala, Uganda.

Asfaw Telaye, Tesfaye Getachew, Beyene Demtsu. 1994. Genetics and Breeding of Faba Bean. In: Asfaw Telaye, Geletu Bejiga, Saxena, Mohan C, Solah, Mohamoud B, eds. 1994. Coolseason Food Legumes Review Conference, 16-20 December 1993, Addis Ababa, Ethiopia.

Cochran WG, Cox M.1957. Experimental Designs. John Wiley and Sons, Inc. New York.

CSA (Central Statistical Authority). 2011. Agricultural sample survey. Report on area and production for major crops (private peasant holdings, *meher* season). Addis Ababa, Ethiopia.

Gemechu Keneni, Belay Simane, Getnet Gebeyehu. 1997. Genetic Diversity of groundnut germplasm in Ethiopia. Ethiopian Journal of Agricultural science **16**, 1-13

Gemechu Keneni, Mussa Jarso, Tezera Wolabu. 2003. Faba bean (*Vicia faba* L.) genetics and Breeding Research in Ethiopia: A Review. In: Ali kemal, kenneni Gemechu, Ahmed Seid, Malhatra Rajendra, beniwal Surendra, Makkouk Khaled, Halila MH, eds. Food and Forage legumes of Ethiopia: Progress and prospects. Proceedings of the workshop on Food and Forage Legume, 22-26 September 2003. Addis Ababa, Ethiopia.

Gemechu Keneni, Mussa Jarso, Tezera Wolabu, Getnet Dino. 2005. Extent and pattern of genetic diversity for morph-agronomi traits in Ethiopian highland pulse landraces II. Faba bean (*Vicia faba* L.). Genetic Resources and Crop Evolution **52**, 551-561.

Hailu T. 1988. Variability and association of characters in tef (*Eragrostis tef* (Zuc) Trotter) cultivars. M.Sc. Thesis. Alemaya University of Agriculture, Ethiopia.

Johnson HW, Robinson HF, Comstock RE.1955. Estimates of Genetic and Environmental Variability in Soya beans. *Agronomy Journal* **47**, 314-318.

McCormick KM. 2004. Fenugreek (*Trigonella foenum-graecum*) for south-eastern Australian farming systems. Ph.D. thesis, School of Agriculture and Food Systems, the University of Melbourne, Victoria, Australia.

Miller PA, Williams C, Robinson HF, Comstock RE. 1958. Estimates of genotypic and Environmental variances and co-variances in upland cotton and their implications in selection. *Agronomy Journal* **50**,126 –131.

Million Fikreselassie, Habtamu Seboka. 2012. Status of Completed Experiments in Highland Pulses Research Program of Haramaya University, Ethiopia. Instasci Journal of Agronomy and Marine Sciences (In press *With manuscript- id Instasci01202042)*

Fikreselassie Million, Habtamu Zeleke, Nigussie Alemayehu. 2012. Genetic Variability of Ethiopian Fenugreek (*Trigonella foenum-graecum* L.) Landraces. *Journal of Plant Breeding and Crop Science* **4**, 39-48.

Newton Z, Ann C, Rowland M. 2011. Grail legume impacts on soil biological processes in sub-Saharan Africa. African Journal of Plant sciences **5**, 1-7.

Qui J, Mosjidis JA, Williams JC. 1994. Seedling growth as affected by seed weight in common Vetch. *Agronomy journal* **86,** 251-255.

SAS Institute. 1996. SAS/STAT guide for personal computers, version 6.12 edition. Cary, NC: SAS Institute Inc.

Shukla GP, Sharma RK. 1978. Genetic variability, correlation and path analysis in fenugreek. *Indian Journal of Agricultural Science* **48**, 518-521.

Singh BD. 1990. Plant Breeding: Principles and methods. Kalyani Publishers, New Delhi-Ludhiana .

Yohannes Degago. 2000. Faba bean (*Vicia faba*) in Ethiopia. Institute of Biodiversity Conservation and Research (IBCR) Addis Ababa Ethiopia.

Singh RK, Chaudhary BD.1999. Biometrical Methods in Quantitative Genetics Analysis, Kalyani publishers, New Delhi.

Solomon Admassu. 2006. Genotype X Environment Interaction and Correlation Among Some Stability Parameters of Yield and Its Attributes in Maize (Zea mays L). MSc thesis presented to the School of Graduate Studies of Haramaya University, Ethiopia.

Steel RG, Torrie JH. 1984. Principles and procedure of statistics. PP 137-167.

Tanner DG, Amanuel Gorfu, Kassahun Zewudu. 1991. Wheat agronomy research in Ethiopia.p 95-135.In: Haile G/Mariam, Tanner DG, Mengistu Huluka, eds. What Research in Ethiopia: A Historical perspective. IAR/CIMMYT, Addis Ababa.