AJBS Asian Journal of Biological Sciences

OPEN ACCESS

Evaluation of Faba Bean (*Vicia faba* L.) Genotypes for Yield and Disease Resistance at Werabe District, Central Ethiopia Region

[1]Muhammed Sitote, [1]Shimelis Mohammed, [1]Mukerem Elias, [1]Bilal Temam and [2]Asnakech Tekalign

[1]Southern Agricultural Research Institute, Werabe Agricultural Research Center P.O. Box 21 Werabe, Ethiopia

[2]Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, P.O. Box 2003, Addis Ababa, Ethiopia

ABSTRACT

Background and Objective: The productivity of faba beans is only 2.1 ton ha^{-1} far less than the crop's potential of 5.2 ton ha^{-1}, despite its enormous importance and area coverage. The current study was started to evaluate and identify high-yielding and disease-resistant faba bean genotypes for the study area. **Materials and Methods:** This experiment was carried out at the Worabe Research Center (WARC) main station in Alibazer districts during the 2017 and 2018 cropping seasons. For the current study, thirteen faba-bean genotypes and two standard checks (Degaga and Dosha) were collected from Holleta Agricultural Research Center. A randomized complete block design (RCBD) with four replications was used. Six agronomic traits and disease severity data were collected and analyzed using appropriate software (SAS 9.3). **Results:** The combined analysis showed no statistically significant variation among tested genotypes and years. However, the genotypes revealed highly significant variation for the tested traits. Accordingly, the mean yield of the genotypes evaluated in this experiment ranges from 1753.25^{f} kg ha^{-10} (genotype 'cool-0008') to 3776.75^{a} kg ha^{-1} (genotype 'cool-0030'). Only when genotype by environment interaction lacks significance do the relative means of genotypes across environments serve as sufficient indicators of genotypic performance. **Conclusion:** Therefore, genotypes 'cool-0030' and 'cool-0018' were the two highest-performing genotypes across the tested environments. Therefore, genotypes 'cool-0030' and 'cool-0018'which produced lower disease severity coupled with higher grain yield, can be recommended for cultivation in the study area.

KEYWORDS

Faba bean, disease resistant, *Vicia faba* genotypes, disease severity, yield-related traits, faba bean growing regions

INTRODUCTION

The annual herbaceous crop faba bean (*Vicia faba* L.) has a diploid chromosome number of 2 n is 12 and belongs to the Fabaceae family[1]. The multipurpose legume faba bean (*Vicia faba* L.) is an important source of protein for Ethiopia's rural population[2]. The faba bean (*Vicia faba* L.) is a cool-season crop that is grown as both a grain and a green manure legume around the world. It is the first food legume produced on a global scale[3]. Following China, Ethiopia is the world's second-largest producer of faba beans.

ISSN: 1996-3351 (Print)
https://doi.org/10.3923/ajbs.2024.462.468

Received: 21 Apr. 2024
Accepted: 29 Jun. 2024
Published: 30 Sep. 2024

Additionally, it is Ethiopia's most significant food legume crop in terms of area covered and annual production volume[4]. Approximately 511,908.4 ha of land were planted with faba beans each year in the country and 3,682,512 smallholder farmers farmed the crop[4]. Through, nitrogen fixation, it improves soil fertility and is a promising rotational crop[3]. Furthermore, the crop increases soil fertility because it fixes large amounts of atmospheric nitrogen and leaves a significant amount of N-related yield effect for subsequent crops due to its large biomass[5]. Furthermore, it provides the nation with foreign exchange[3].

The productivity of faba beans is only 2.1 ton ha^{-1} [4] far less than the crop's potential of 5.2 ton ha^{-1}, despite its enormous importance and area coverage. There are likely a variety of biotic and abiotic factors responsible for this among which the utilization of outdated, low-yielding local cultivars and the absence of enhanced, high-yielding varieties[6]. According to Goa and Kambata[7], the faba bean (*Vicia faba* L.) is the most widely grown pulse crop in Ethiopia in terms of both production volume and area covered. Despite being a significant crop in Ethiopia, the Southern Region's production and productivity are only 2030 kg ha^{-1} [8] because of diseases, a lack of improved varieties and uneven agronomic practices.

It demonstrates that in order to address the low productivity and production of faba beans in the study area, variety should be consistently released in the area. In order to gather relevant data on faba bean performance, this study used genotypes of the beans. The grain yield performance of various genotypes can be analyzed and interpreted using a variety of statistical techniques. Nonetheless, the current study uses ANOVA, which is crucial for splitting variance. Better yielding varieties are highly sought after by farmers in the study areas in order to maximize their output, which raises income and enhances family living standards. In order to find high-yielding and disease-resistant faba bean varieties for the study area, the current study was started.

MATERIALS AND METHODS

Description of the study area: This experiment was carried out at the Worabe Agricultural Research Center (WARC) main station in the Worabe town administration Alibazer districts during the 2017 and 2018 cropping seasons. It is located in the Siltie Zone, at an Altitude of 2311 m above sea level, with a mean annual rainfall of 1312 mm, an average temperature of 21.150°C, loam soil texture and latitude/long coordinates of 7087'23"/38015'01".

Experimental treatment design and agronomic practice used: For the current study, thirteen faba-bean genotypes and two standard checks (Degaga and Dosha) were collected from Holleta ARC during the main cropping seasons of 2017 and 2018. A randomized complete block design (RCBD) with 4 replications was used. Sowing was done by hand in 6.4 m^2 plots with four rows measuring 1.6 and 0.4 m within a row, 0.10 m between plant spacing and a length of 4 m. The seed rate was set at 200 kg ha^{-1} and the fertilizer rate was 19% N, 38% P_2O_5 and 7% S at planting. The two middle rows, each measuring 3.2 m^2, were harvested and the yield per hectare was computed.

Collected data and analysis: The days to 50% flowering (No.): Days to flowering were recorded by counting the number of days starting from the planting date to the plants starting to flower. The data was recorded from central rows on the plot base:

- **Plant height (cm):** It was recorded by measuring the height of five randomly selected plants from central rows of each plot in centimeter starting from ground to the tip of the plant and the average is taken for data
- **Pod per plant (No.):** Average number of pods per plant collected from central rows of five randomly selected plants on the plot base
- **Seed per pod (No.):** Average number of seeds per pod collected from central rows of five randomly selected plants on the plot base

- **Yield (kg/ha):** Yield was measured from each plot from the two central rows in grams using a sensitive balance and subjected to analysis after it adjusted its moisture
- **Thousand seed weight (gm):** A thousand seeds weight were counted and weighed in grams using a sensitive balance on the plot base
- **Disease severity (1-9 scale):** Disease severity of chocolate spot, rust, ascochyta blight and powdery mildew were recorded from each plot using 1-9 scale and subjected to analysis

For the combined analysis of variance over years, the linear mixed model was applied:

$$Ylmn = \mu+gl+em+bk\ (n)\ m+(ge)\ lm+\varepsilon lmn$$

where, Ylmn is the response of Y trait from the lth genotype, grown in the nth block of mth year. The μ is Grand mean, gl is the effect of the lth genotype, em is the effect of mth year, bk (n) m is the effect of nth block/rep in mth year. The (ge) lm is the interaction between the lth genotype and mth year. The εlmn is Pooled error.

Statistical analysis: All measured quantitative parameters were subjected to Analysis of Variance (ANOVA) using SAS 9.3 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

Performance of medium-seeded faba bean genotypes for yield and yield-related traits: The combined Analysis of Variance (ANOVA) for seven traits over the years showed a highly significant ($p<0.01$) difference for genotypes (g) for most traits; however, it revealed a non-significant ($p<1.00$) difference for years (y) and the genotype by years interaction (GEY) on most of the traits considered (Table 1). The presence of non-significant variations among the genotypes over the year indicates that the tested faba bean genotypes showed stability in their performance to tested traits; as a result, the combined analysis suggests that the tested location is supposed to generate a general recommendation. On the other hand, the presence of highly significant variation among tested faba bean genotypes shows the inherent genetic potentials of faba bean genotypes.

It has important ramifications for Ethiopian faba bean breeders who can select easily and release potential medium-seeded faba bean genotypes for research and related agroecologies. This result was in line with that of Alemayehu *et al.*[1], who found that the genotypes of faba beans tested differed significantly for the agronomic traits tested. Similar findings were reported by Derese[9], Kindie and Nigussie[10] and Degife and Kiya[11] and others regarding the significance of genotype variation for yield and related agronomic traits.

Days to 50% flowering: The study found a significant difference in the number of days to 50% flowering between genotypes and years (Table 1). This suggests that the testing years and genotypes under evaluation differed in terms of environmental factors and days to 50% flowering. Specifically, the faba-bean genotype 'cool-0008' (65.25^{a}) had the longest days to 50% flowering, while genotype 'cool-0031' (58.75^{d}) had the shortest flowering date that might avoid the terminal drought stress (Table 2). Asrat *et al.*[4] and Kindie and Nigusie[10] reported similar findings.

Plant height (cm): Among the genotypes that were tested, there was a highly significant variation in plant height (Table 1). The genotypes "cool-0030" (141.65^{a}), "cool-0031" (141.3^{a}) and "cool-0039" (141^{a}) had the longest plant heights on record, while "cool-0024" (118^{c}) had the shortest (Table 2). These genotypes may possess a high vegetative mass, which is crucial for augmenting grain yield. Accordingly, earlier studies were published by Degife and Kiya[11] and Tadele *et al.*[12].

Table 1: Combined analysis of medium seeded faba bean genotypes for yield and yield related traits combined over year

Source	DF	DF (No.)	PH (c)	PPP (No.)	SPP (No.)	YLD (kg/ha)	TSW (gm)
trt	14	32.84**	323.26*	33.99*	0.11	147683.17**	449205.15
trt×year	14	1.39*	97.99	0.85	0.14	2.133^{ns}	316555.21
rep	3	36.40*	1456.7**	119.23**	3.03**	144184.98**	345787.71
rep (year)	3	0.88	100.07	0.51	0.36	5.267^{ns}	312716.14
Year	1	8.53	99.00	4.40	1.40	16.13^{ns}	310388.40
Error	84	12.53	181.47	15.89	0.18	14360.58	324347.19

**Is indicates highly significant difference, *is indicates significant difference and ^{ns}is indicates non-significant difference. DF: Days to 50%flowering, pH: Plant height, PPP: Pods per plant, SPP: Seeds per pod, Yld: Yield and TSW: Thousand seeds weight

Table 2: Mean values of fifteen medium-seeded genotypes for seven agronomic traits at Worabe District combined over the year

Genotype	DF (No.)	PH (cm)	PPP (No.)	SPP (No.)	YLD (kg/ha)	TSW (gm)
Degaga	60.25^{cd}	124.25^{bc}	17.5^{abc}	3.3^{ab}	2772.56^{bc}	494.5^{ed}
cool-0012	63^{abc}	133.25^{ab}	17.5^{abc}	3.2^{ab}	2503.25^{cd}	608^{ab}
cool-0030	61.25^{bcd}	141.65^{a}	25.12^{a}	3.3^{ab}	3776.75^{a}	573.5^{bc}
cool-0025	58.25^{d}	133.65^{ab}	14.12^{cd}	3.2^{ab}	2051.63^{ef}	579^{b}
cool-0011	62..5^{abc}	128.5^{abc}	14.12^{cd}	3.2^{ab}	1133.94^{g}	433^{ef}
cool-0002	64.25^{ab}	133.6^{ab}	18.8^{ab}	3.2^{ab}	2174.19^{de}	553^{bcd}
cool-0018	63^{abc}	137.3^{ab}	15.8^{bcd}	3.2^{ab}	3593.5^{ab}	545^{bcd}
cool-0035	62.25^{abc}	135.25^{ab}	16.3^{abc}	3.1^{ab}	2343.5^{cde}	569^{bc}
cool-0034	64^{ab}	135.8^{ab}	12.3d	3.2^{ab}	2634.75^{bc}	548^{bcd}
cool-0003	62.5^{abc}	131.8^{ab}	19.8a	3.3^{ab}	2412^{cd}	571^{bc}
cool-0031	58.75^{d}	141.3^{a}	15.5^{bcd}	3.1^{ab}	2321.75^{cde}	547.5^{bcd}
cool-0024	61^{bcd}	118^{c}	15.3^{bcd}	3.2^{ab}	2531.5^{bc}	533.75^{bcd}
cool-0039	60.25^{cd}	141^{a}	18.1^{ab}	3.2^{ab}	2142.13^{ed}	505^{cd}
cool-0008	65.25^{a}	133.25^{ab}	15.3^{bcd}	3.3^{ab}	1753.25^{f}	398.25^{f}
Dosha	64^{ab}	131.5^{ab}	13.75^{cd}	3.6^{a}	2267.88^{de}	655^{a}
CV (%)	5.92	6.62	26.02	10.26	16.32	13.20
LSD at 5%	3.4	13.4	3.9	0.42	119.15	71.21

Means with similar letters in the same columns are not significantly different, DF: Days to 50%flowering, pH: Plant height, PPP: Pods per plant, SPP: Seeds per pod, YLD: Yield and TSW: Thousand seeds weight

Number of pods per plant: Table 1 displays the significant differences ($p<0.05$) in the number of pods per plant between the genotypes that were tested ($p<0.01$). Table 2 shows that genotype 'cool-0030' (25.12^{a}) had the highest pod count, while 'cool-0034' (12.3^{d}) had the lowest. Regarding the quantity of seeds in each pod, there was no statistically significant variation across genotypes (Table 1).

Grain yield (kg ha^{-1}): The results of the analysis of variance showed that the grain yield of fifteen medium-seeded faba bean varieties was significantly influenced by genotypes (g) (Table 1). While there were no differences between the years indicating the yield potential suitability and stability of the test genotypes for faba-bean production, the presence of significant variations among the genotypes indicates differences in the inherent genetic potential of the genotypes that make it easy to select. The highest yielding faba-bean genotype was 'cool-0030' (3776.75^{a}), followed by 'cool-0018' (3593.5^{ab}); the lowest mean grain yield was 'cool-0008' (1753.25^{f}) (Table 2).

Thousand seed weight (g): The results of the analysis of variance showed that the thousand seed weights varied significantly ($p<0.01$) (Table 1). The genotype Dosha (655^{a}) had the highest mean thousand seed weight, followed by "cool-0012" (608^{ab}); genotype "cool-0008" (398.25^{f}) had the lowest mean seed weight (Table 2).

Performance of medium-seeded faba bean genotypes for diseases reactions: A highly significant difference in the tested genotypes for disease reactions was found by the analysis of variance (Table 3). Nevertheless, the combined analysis showed that their disease reactions did not significantly change over the course of the tested years. It suggests that the study could therefore offer a broad recommendation for the tested site.

Table 3: Mean square values of fifteen medium seeded faba bean genotypes for disease reaction combined over the year

Source	DF	CSP	Rust	ASBL	PMDW
trt	14	2.94**	1.97*	1.17*	0.972*
trt×year	14	2.42^{ns}	2.78^{ns}	1.92^{ns}	1.60^{ns}
Year	1	0.15^{ns}	0.01^{ns}	0.01^{ns}	0.67^{ns}
Error	90	1.95	1.80	2.55	1.38

**Is indicates highly significant difference, *is indicates significant difference and ^{ns}indicates non-significant difference. CSP: Chocolate spot, ASBL: Ascochyta blight and PMDW: Powdery mildew

Table 4: Disease reaction of fifteen medium-seeded faba bean genotypes for four diseases combined over the year

Genotype	CSP	Rust	ASBL	PMDW
Degaga	5.5^{abc}	5.5^{ab}	2.5^{a}	1.6^{ab}
cool-0012	4^{d}	5.5^{ab}	2.75^{a}	1.8^{ab}
cool-0030	2^{f}	2^{d}	2.5^{a}	1.7^{ab}
cool-0025	5.75^{ab}	5^{bc}	2.25^{a}	2.6^{a}
cool-0011	5.25^{abcd}	5^{bc}	2.5^{a}	2.2^{ab}
cool-0002	5.25^{abcd}	4.5^{bc}	3.25^{a}	1.3^{b}
cool-0018	3^{e}	2.5^{c}	2.25^{a}	2.1^{ab}
cool-0035	6.25^{a}	4.5^{bc}	2^{a}	2.6^{a}
cool-0034	5.5^{abc}	4.25^{c}	2.75^{a}	1^{a}
cool-0003	5^{abcd}	5.25^{abc}	1.75^{a}	2^{ab}
cool-0031	5.25^{abcd}	5.5^{ab}	2^{a}	1.7^{ab}
cool-0024	5.75^{ab}	5.25^{abc}	2.75^{a}	2^{ab}
cool-0039	5^{abcd}	5.25^{abc}	2.25^{a}	2.3^{ab}
cool-0008	4.25^{cd}	5.5^{ab}	2.25^{a}	2^{ab}
Dosha	5^{abcd}	6.25^{a}	2.75^{a}	1.8^{ab}
CV (%)	5.4	10.2	6.8	7.8
LSD at 5%	1.3	1.25	1.5	1.1

Means with similar letters in the same columns are not significantly different, CSP: Chocolate spot, ASBL: Ascochyta blight and PMDW: Powdery mildew

Of the faba bean genotypes that were tested, faba bean genotype "cool-0035" had the highest severity of chocolate spot disease (6.25^{a}), while genotype "cool-0030" had the lowest severity (2^{f}), followed by genotype "cool-0018" with a mean value of 3^{e} (Table 4). The current findings are inconsistent with a previous study conducted in Ethiopia by Mitiku and Wolde[13] and Yitayih and Azmeraw[14], which reported varying levels of chocolate spot disease severity among evaluated faba bean genotypes. The need to assess and identify resistant varieties to be produced in potential agro-ecologies is suggested by the varying responses of improved faba bean varieties to chocolate spots. However, Sahile *et al.*[15] did not find any statistically significant differences in chocolate spot resistances among the faba bean varieties. This observation may be explained by the fact that disease resistance varies among the varieties or by the unfavorable environment that prevents the pathogen from expressing its disease-causing genetic potential.

Among the tested faba bean varieties, the highest (6.25^{a}) rust disease severity was assessed on faba bean genotype Dosha, while the lowest severity (2^{d}) of this disease was recorded for the 'cool-0030' genotype with a mean value of 2^{d} (Table 4). Regarding the severity of ascholyta blight and powdery mildew disease, there were non-significant variations among tested faba bean genotypes (Table 3).

Given that yield is the outcome of the interactions between different plant characteristics and environmental conditions throughout a plant's development, the genotype ranking based on grain yield is a valid indicator of genotypic performance. According to Table 3, the genotypes evaluated in this experiment have mean yields ranging from 1753.25 kg ha^{-1} (genotype 'cool-0008') to 3776.75 kg ha^{-1} (genotype 'cool-0030'). Only in the absence of genotype by environment interaction are the relative means of genotypes across environments suitable markers of genotypic performance. The two best-performing genotypes in all of the tested environments were thus "cool-0030" and "cool-0018".

CONCLUSION AND RECOMMENDATION

The combined analysis of variance for the study showed that there were notable differences in grain yield between the tested genotypes. Ultimately, it was discovered that the genotype "cool-0030" produced the most faba beans out of all the genotypes examined and it is therefore advised for cultivation in the study area. Additionally, the study revealed that the severity of rust and chocolate spot diseases varied significantly from one another. In this regard, genotypes 'cool-0030' and 'cool-0018' produced lower disease severity for chocolate spot and the lowest disease severity of rust in faba bean genotype 'cool-0030' with an increased amount of yield than the other tested varieties. Therefore, to control the faba bean disease epidemic in faba bean-growing regions, genotypes "cool-0030" and "cool-0018," which generated lower disease severity along with higher grain yield, can be regarded as moderately resistant varieties.

SIGNIFICANCE STATEMENT

Farmers in the Central Ethiopian regions face difficulties in obtaining genotypes of faba beans that are resistant to disease and have high yields. They continue to produce faba beans in the area with low productivity using their outdated, locally released varieties. Highlighting the significance of the research, this will provide detailed information on the identification of genotypes with higher yields and resistance to disease. The outcome suggests that it was identified two faba bean genotypes ("cool-0030" and "cool-0018,") which are high yielders and with better disease resistance. Hence it is important to control the faba bean disease epidemic in faba bean-growing regions. The results will also contribute to an increase in the production of this important crop under farmer conditions.

ACKNOWLEDGMENTS

The authors greatly acknowledge Holleta ARC for giving the faba bean genotypes and Werabe ARC for assisting in successful the experiment.

REFERENCES

1. Alemayehu, T.Y., K. Amare, D. Belay and H. Abebe, 2024. Faba bean (*Vicia faba* L.) variety evaluation for disease resistance, yield, and agronomic traits in South Gondar, Ethiopia. Int. J. Agron., Vol. 2024. 10.1155/2024/5490629.
2. Bedada, A.F., G.S. Bedada and N.K. Firisa, 2024. Performance evaluation and adaptability of improved faba bean (*Vicia faba* L.) varieties in the highlands of North Shewa Zone, Oromia. Am. J. Life Sci., 12: 24-32.
3. Zong, X., T. Yang and R. Liu, 2019. Faba Bean (*Vicia faba* L.) Breeding. In: Advances in Plant Breeding Strategies: Legumes, Al-Khayri, J.M., S.M. Jain and D.V. Johnson (Eds.), Springer, Cham, Switzerland, ISBN: 978-3-030-23400-3, pp: 245-286.
4. Asrat, Z., A. Tariku, T. Begna, H. Gichile and W. Yali, 2022. Performance evaluation of improved Faba bean (*Vicia faba* L.) varieties for yield and yield attribute traits in highland areas of West Hararghe, Eastern Ethiopia. Adv. Crop Sci. Technol., Vol. 10.
5. Watson, J., B. Zheng, S. Chapman and K. Chenu, 2017. Projected impact of future climate on water-stress patterns across the Australian wheatbelt. J. Exp. Bot., 68: 5907-5921.
6. Ademe, A., Y. Ebabuye, M. Gelaye, S. Gezachew and G. Telahun, 2018. Survey of faba bean (*Vicia faba* L.) diseases in major faba bean growing districts of North Gondar. Afr. J. Plant Sci., 12: 32-36.
7. Goa, Y. and E. Kambata, 2017. Participatory on farm evaluations and selection of improved faba bean (*Vicia faba* L.) varieties in four districts of South Ethiopia. Adv. Crop Sci. Technol., Vol. 5 10.4172/2329-8863.1000293.
8. Dobocha, D. and D. Bekele, 2021. Faba Bean Agronomic and Crop Physiology Research in Ethiopia. In: Legumes Research, Jimenez-Lopez, J.C. and A. Clemente (Eds.), IntechOpen, London, United Kingdom, ISBN: 978-1-83969-490-5 Pages: 480.

9. Derese, T., 2022. Evaluation of faba bean (*Vicia faba* L.) varieties for yield and yield contributing traits in the southern parts of Ethiopia. Int. J. Res. Stud. Agric. Sci., 8: 18-22.
10. Kindie, Y. and Z. Nigusie, 2019. Participatory evaluation of faba bean (*Vicia faba* L.) varieties for yield and yield components in Wag-Lasta, Eastern Amhara, Ethiopia. East Afr. J. Sci., 13: 7-14.
11. Zebire, D.A. and K.A. Tadesse, 2018. Evaluation of faba bean (*Vicia faba* L.) varieties for yield and reaction to chocolate spot disease at Chencha, Southern Ethiopia. Afr. J. Plant Sci., 12: 155-163.
12. Tadele, M., M. Jarso, S. Argaye, A. Tekalign and N. Tilahun *et al*., 2021. Performance of large seeded faba bean genotypes for yield and related agronomic traits in different parts of Ethiopia. East Afr. J. Agric. Biotechnol. 4: 1-11.
13. Mitiku, A. and M. Wolde, 2015. Effect of faba bean (*Vicia faba* L.) varieties on yield attributes at Sinana and Agarfa Districts of Bale Zone, Southeastern Ethiopia. Jordan J. Biol. Sci., 8: 281-287.
14. Yitayih, G. and Y. Azmeraw, 2017. Adaptation of faba bean varieties for yield, for yield components and against faba bean gall (*Olpidium viciae* Kusano) disease in South Gondar, Ethiopia. Crop J., 5: 560-566.
15. Sahile, S., C. Fininsa, P.K. Sakhuja and S. Ahmed, 2008. Effect of mixed cropping and fungicides on chocolate spot (*Botrytis fabae*) of faba bean (*Vicia faba*) in Ethiopia. Crop Prot., 27: 275-282.