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RESEARCH ARTICLE

Genotype X Environment Interaction and Coefficient Regression in Some Genotypes of Faba Bean (Vicia faba L)

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ABSTRACT

This study was conducted during the agricultural season 2019 and 2020 to study the stability of thirteen genotypes of Faba bean (*Vicia faba* L) in two locations, Dohuk and Amadiya, which are: 1-JFVFPvS6xoAzz. 2- JFVFPY0cUVcfP. 3- JFVFPfpRXDKoB. 4- JFVFPiVNWsuAc. 5- JFVFP21Hq13l8. 6- JFVFPIqk7yPUI. 7- JFVFPUjauruAK. 8- JFVFPQkjOOVN8. 9- JFVFPCixLJlCy. 10- JFVFP9fH82cZR. 11- JFVFPVXU3Yk9v. 12- JFVFPM4hNfKjC. 13- JFVFP9fH82cZR.). The data were recorded for the following traits: plant height (cm), number of pods plant-1, pod length, number of seeds plant, and dry seed yield plan-1t. The results of the analysis of variance showed that the genetic compositions differed significantly among themselves for these traits according to Duncan's multiple range test at a probability level of 5 and 1%, In addition to the effect of environmental variation, it had a significant effect on the studied traits of these genotypes. While the genotype (11) outperformed in the trait of plant height and dry seed yield plant-1, and the genotype (4) in the trait of number of pods plant-1 and number of seeds plant-1, while the values of s2d reached high and positive values for the traits of plant height for the genotypes (1, 10, 11 and 12), and for the trait of number of pods plant-1 was achieved by the genotype (4) and for the trait of number of dry seeds plant-1 it was recorded by genotypes (4, 5, 7 and 9), while the regression coefficient had positive and negative values between the genotypes for the studied traits.

INTRODUCTION

Faba bean one of the most of important, productive efficient and valuable legumes food crops [1 and 29]. The productivity in Iraq of fresh and dry bean attained about a 1541.7 and 1267.2 Kg. ha $^{-1}$ respectively in 2019 season. It grown for fresh grain and seed drayed as a sources of protein (29.57-31.83%) , carbohydrate (52.26-54.6%) , Mineral elements (0.81-1.24%) and fibers (10.88-11.96%) which varying according to cultivars, uses and their benefits, [31].Growth of plant affects by environments (Salinity, temperature and moisture), Genetic (Strains) and agricultural practices (Methods and sowing dates and fertilization) , therefore, new genotypes need to be tested in stability in their traits in a wide range of environmental conditions. The differences in stability revers the interactions of their genetic base with the environments that select and distinguish the genotypes from each other. Stability methods are necessary to determination the stable genotypes which hold change their traits in different environments and regard as phenotypic and genotypic stable [13 and 7]. Two parameters (bi: coefficient of regression means genotypes and S2 di: deviation from regression line) are calculate in stability method of [17,45] that explain the nature of genotypes behavior and if can be predicted or non-predicted by linear relationship. Accordingly stable genotype has coefficient of regression equal to one and no significant division from regression line and has high yield in each environmental condition. Also, significant of coefficient of regression refer to the main important effects of environments then can be predicted by linear function, on the other hand the significancy of deviation from regression refer to non-dependency genotypes of linear function and can't be predicted. Genotypes interactions interpretations involve three concepts: first, when their responses to the environments are similar to the general mean, second: the variation at different environments are diminish and third: low residual variances from regression [28 and 10]. A researcher [18,44] mentioned that parallel responses in yield or other traits to the typical line referto the high stability of genotypes. The quoracy of determination interactions with environments which affect Faba bean seed yield and its components traits through behavior genes regarded a realchallenge of plant breeder [32 and 34]. Stable genotypes noticed especially in number of pods plant^{-1} and 100 seed yield [4]. High and constant seed yield in different environments are important in improving superior strains through breeding programs [23, 43].

Agricultural productivity is highly affected by climatic change in terms of fluctuations in temperatures, precipitation, and extreme weather events, as well as variability in seasonality. At present, sustainable agriculture is threatened by climate change, as a reduction in crop production is expected in most regions [1]. Moreover, the changing conditions lead to resource problems, such as water shortage, pollution, soil deterioration, and ultimately food security issues in resource-poor regions [24,46].

The impact of climate change on agriculture can be reduced by the modifying farming practices, and complementary to this, by using appropriate crops and varieties adapted to new climatic conditions. In regards, modern breeding must fulfill several objectives: harmonize agricultural production and environmental condition; ensure food and seed abundance, security and quality; and secure climate robustness [27]. Thus, breeding adaptive traits is required to increase the resilience to broad-spectrum stresses and maintain productivity, food security, and agricultural sustainability. At the same time, the demand for environmentally friendly crops and for food security has increased and has led to the establishment of cropping systems that include annual grain legumes [16]. Especially in the European Union, the policy is to greatly increase the domestic production of grain legumes [12 and 41].

Despite that grain legumes are often characterized as climate-smart crops, they are mainly cultivated in marginal environments where the range and intensity of abiotic and biotic stresses are expected to increase, therefore, improving their resilience to climate change is of ultimate importance to provide food and nutritional security. Their narrow genetic diversity has always been a major drawback to their improvement for adaptability. To this end, plant breeders are required to intensifyefforts to identify or develop diverse germplasm lines that can tolerate or even take advantage of climatic abnormalities [11 and 15].

Grain yield is a very complex trait which is strongly influenced by genotype (G), environment (E) and genotype x environment (GE) interaction [40 and 43]. GE interaction is of major importance for breeders, given that it reduces the association between phenotypic and genotypic values across environments [40 and 33]. It also affects the identification of linkage test environments, the distribution of resources within a breeding program and the choice of germplasm and breeding strategy [14]. GE interaction is a confrontation in the case of legume breeding as previous studies have suggested that a high proportion of variance due to environment (E) and GE interaction on the expression of grain yield in pulse crops including Faba bean [25 and 20].

Stability indicates that the genotype positively responds to any refinement in environmental conditions and can perform above the mean in different locations [35]. This attitude is of great substantial for both plant breeders and farmers. In parallel, multi-location field experiments were on a large scale used in order to improve the adaptability and depress the environmental effects on genotype behavior [30], chiefly for yield, which is significantly affected by ecological conditions in terms of stability and adaptation [38].

The genotype (G), environment (E), and genotype × environment interaction (GEI) all have a significant impact on the seed yield, which is an extremely complex characters [40]. Under various environmental situations, the GEIs lead genotypes to respond differently [42]. Given that GE interaction decreases the correlation between phenotypic and genotypic values across locations, it is crucial for breeders [14]. It also has an impact on selecting appropriate test conditions, allocating resources within breeding programs, and selecting breeding germplasm and tactics [25 and 20]. In the case of breeding legumes, GE interaction presents a difficulty because prior research has indicated that a significant amount of the variation in seed production in pulse crops, including Faba bean, is influenced by both the environment (E) and GE interaction [26 and 20]. Environmental variation has a major effect on the variation of yield (up to 80% or higher) [38]. in developed pure lines with narrow genetic base, but genotypes and GE interaction are more relevant for germplasm evaluation and selection and they must be considered simultaneously when selecting a genotype; in other words, an ideal genotype should have both highmean yield performance and high stability across environments [42 and 14].

This research aimed to evaluate the performance of 13 Faba bean genotypes, including a local check variety, across two planting dates and two locations, focusing on seed yield and its components. The study also assessed the stability of these genotypes in four distinct environments created by the combination of planting dates and locations. Additionally, it sought to estimate components of phenotypic variance and various genetic parameters related to the genotypes.

MATERIAL AND METHODS:

Thirteen genotypes of Faba bean (*Vicia faba L*) (1- JFVFPvS6xoAzz. 2- JFVFPY0cUVcfP. 3- JFVFPfpRXDKoB. 4- JFVFPiVNWsuAc. 5- JFVFP21Hq13l8. 6- JFVFPIqk7yPUI. 7- JFVFPUjauruAK. 8-JFVFPQkjOOVN8. 9- JFVFPCixLJlCy. 10- JFVFP9fH82cZR. 11- JFVFPVXU3Yk9v. 12- JFVFPM4hNfKjC. 13- JFVFP9fH82cZR.) (Tablel 1). Cultivated during growing season, 2019–2020 on November and December sowing in a randomized complete block design (RCBD) with three replications at two different locations (Duhok and Amidi) regions with two planting date for each location with three replications. Each genotype was planted in 3 rows with 3 m long and 40 cm between rows three seeds were placed in each hole at a depth of 3-5 cm.

Data recorded and statical analysis

Data were recorded on plant heigh (PH), number of pods plants^{-1} (NPP), pod's length plant (cm) (PLP), number of seeds per plant^{-1} (NSP), dry seeds yield plant $^{-1}$ (DSY). For comparison of genotype means for variance [4]. The analysis of variance was done for each environment and pooled analysisover environments to determine regression coefficient (bi) and deviation from regression (S^2d) which were used as stability parameters to determine the stability of the genotypes over environments [8]. Genotypes with high mean for each character with non-significant value of bi andS^2d were determined as stable genotypes.

$Yij = \mu + biIj + \delta ij + eij.$

Since Yij refer to the mean of variety (i) in the environment (j),

bi is the regression coefficient of variety (i) at the given environmental index, which means the variety response to environmental change,

Ij is the environmental index, which is defined as the deviation of the mean of all varieties in the given environment from the general mean,

δij the deviation from the regression of the variety (i) at environment

(j)eij are the mean of experimental error.

Table 1. Pedigree and origin of Faba bean genotypes.

Seq	Genotype	Pedigree
1-	Bang-13	JFVFPvS6xoAzz
2-	Bang-22	JFVFPY0cUVcfP
3-	Bang-38	JFVFPfpRXDKoB
4-	Bang-32	JFVFPiVNWsuAc
5-	Bang-3	JFVFP21Hq13l8
6-	Bang-15	JFVFPIqk7yPUI
7-	Bang-26	JFVFP5VA6kjWI
8-	Bang-45	JFVFPPe4qUQUo
9-	Bang-30	JFVFPkXuuJ9Cd
10-	Bang-20	JFVFP9fH82cZR
11-	Bang-27	JFVFPVXU3Yk9v
12-	Bang-44	JFVFPM4hNfKjC
13-	Bang-20	JFVFP9fH82cZR

RESULTS

Table (2) clarify analysis sum of the mean squares for the studied traits. It appears from the table that the compositions different significantly in all the studied traits at the 1% probability level for Duncan's multiple tests. As for the effect of the interaction between e+ (gxe), it manifests from the same table that it was significant in the case of the high of the plant was at a probability level of 1%, and it was significant for the number of pods plant^{-1} and the number of seeds plant^{-1} only at a probability level of 5%. As for the factor e (liner), it was significant for most traits at a probability level of 1%, and it was only significant for the dry seed yield plant^{-1} (gm) at a probability level. 5%. It was significant only for the factor e It was significant only for the number of seeds plant^{-1} at the 1% probability level, while genotype (7) was only significant for the number of pods plan^{-1} at the 5% level, and significant for the number of seeds plant^{-1} at the 5% level for Duncan's multiple test, while only genotype (9) was significant for the number of seeds plant^{-1} at the 1% probability level and the genotype (10) was significant for the plant height and the number of seeds plant^{-1} at the 5% probability level, and the genotype was significant for the characteristic of plant height at the 1% level and for the number of seeds plant^{-1} at the 5% probability level. The genotype was only significant for plant height at the 1% probability level, and genotype 13 was only significant for plant height at the 5% probability level.

Table (2) Variance and meta-analysis of stability for five traits

M.S					d.f	S.O.V
Dry seeds yield/plant (g)	No. of seeds/plant	Pod length (cm)	No. of pods/plant	Plant height (cm)		
**9235.676	**6300.685	**11.814	3515.617**	**1492.896	12	Genotype
1363.257	*941.732	1.440	45.808*	118.945**	39	E+(G×E)
*8430.350	**15127.054	**12.884	602.884**	*1869.83**	1	E (Liner)
318.511	767.858	1.031	49.111	134.759**	12	E × G (Linear)
1573.636	476.392	1.188	22.858	44.304**	26	Pooled division
Variety						
891.8265	6.6775	2.5705	13.525	68.2215*	2	1
2594.847	235.8805	0.9895	20.4385	5.3145	2	-2
367.357	50.3475	0.811	1.8255	15.574	2	-3
504.527	2096.169**	1.745	90.0655**	24.9175	2	-4
121.131	944.627**	0.117	15.4705	3.565	2	-5
398.0225	185.831	0.411	14.2415	29.628	2	-6
2528.316	706.170**	1.022	64.2495*	37.639	2	-7
1061.421	45.8725	0.465	4.408	28.094	2	-8
668.687	948.427**	0.5685	13.1515	43.051	2	9
1895.971	322.661*	3.6975	10.1395	62.2825*	2	-10
5712.165	487.1015*	0.4325	48.977	104.2**	2	-11
692.1495	38.9855	0.098	0.314	81.2585**	2	-12
3020.847	124.348	2.5215	0.3505	72.2055*	2	-13
2503.682	705.540	1.713	20.505	19.945	104	Pooled Error

*Significant at the probability level (5%). ** Significant at the probability level (1%).

Table (3) demonstrated the reliability parameters for the studied traits. The genotypes under study differed significantly among themselves for these traits. We can notice that the genotype 13 achieved the highest average for the plant height trait, the highest B value for the number of pods plant-1, and the highest S2d for the pod length trait, which they were 99.119 cm, 2.879, and 1.950, respectively. The same genotype also recorded the highest number of seeds plant-1, which was 142,000, and the highest value for B for the same trait reached 2.358, and the highest number of seeds plant-1 arrive 1.855. At a probability level of 5 and 1%. As for the S2d value, it was high for genotype 11 and recorded 97.552 for the number of pods plant-1 for the same genotype and 4'877.604 for the dry seed yield of the plant. The B index values were negative for genotypes 1, 6, and 7 for plant height, for genotypes 6 and 10 for the number of pods plant-1, and for cultivars 5 for pod length. The values of the genetic index S2d were also negative for plant height for genotypes 2 and 5, for the number of pods plant-1 for genotypes 3, 8, 12, and 13, and for pod length for genotypes 5, 6, 8, 9, and 11, and they appeared negative for the seed number trait. For each plant for genotypes 1, 3, 6, 8, 12 and 13, and for the dry seed yield trait of the plant for genotypes 3, 4, 5, 6, 9 and 12 at a probability level of 5 and 1%.

Table (4) exhibits the effect of the various factors on the studied traits. The factor of varieties had a significant effect on trait (1), as the sum of the mean squares reached 124.575 and the effect of the environment amounted to 623.277. And the factor of interaction between the genotypes and the environment, as the sum of the mean squares was 76.917, had a significant effect on this characteristic, as for the environment line, was also significant for Duncan's multinomial test at the 1% probability level. The sum of the square of the means reached 118.945. There was also a significant effect on this characteristic for the environment line and the environment x genotypes, as well as pooled deviation. From the same table, the analysis of variance of stability according to the Elberhert and Russel model for trait 2 shows that the highest sum of the mean squares for the effect of the environment factor was 200.961 and for the environment line factor it was 602.884, and the F-calculated values were 6.11 and 26.375, significant at both 5 and 1% probabilities. The line table shows the linear environment and the interaction between the genotype and the environment line against the deviation factor showed that the highest average of the characteristic was for genotype 13, which recorded 385.015, and the lowest average was for both genotypes 6 and 9, which prove 28.514 and 27.408, respectively, and the b factor was positive and negative between the genotypes. The highest positive value was for genotype 13, was 2.879, and the highest negative for the genotype 10, 1.057, while the d2 factor was positive for all genotypes, and the highest value was for genotype 7, has marked 128.499, and the lowest value was for genotype12, which reached 0.628.

When studying stability, the stability analysis for trait 3 shows that the mean sum of squares for the environment was 4.295 and for the environment line was 12.884, and it was significant at the 5 and 1% probability level for Duncan's multiple tests. As for the effect of the environment line and the interaction between genotypes and the environment line against deviation, it appears that the highest average for the trait was for genotype 11, (10.083), the highest average variance was for genotype 9, (10.974), and the lowest variance was for genotype 5, was 0.252. The values of the stability analysis for trait 4 were shown in an analysis table according to (Eberhert and RusselModel). The average sum of squares was high for the effect of the environment factor, amounting to 5,042.351, and for the effect of the linear factor, amounting to 15,127.054. It was significant for the effects of varieties, the environment, and the interaction between them, and for the pooled deviation factor, and that the environment line (Linear) The interaction between the varieties and the environment against deviation shows that the highest average was for genotype 4, which was 112.683, followed by genotype 8, reached 110.367, and the lowest average was for genotype 1 and 2, recorded 84.542 and 85.708. The variance of the mean was the highest value for genotype 8, 13, and 4, were 8,060.458, 6,715.986, and 4,563.0 70 and less the value for genotype 6 was 373.930. It is clear from the analysis of the stability of trait 5 (dry seed yield per plant) that the varieties differed in the stability of this trait at the 5% probability level, as the sum of the mean squares reached 1,176.000, and the environmental factor also reached 2,810.117, and the effect of the interaction between varieties and the environment. It reached 1,242.685 and due to the effect of pooled deviation, which amounted to 1,573.636.

Table 3: Reliability parameters and average of five traits.

Dry seeds yield/plant (g)			No. of seeds/plant			Pod length (cm)			No. of pods/plant			Plant height (cm)			Var.
S^2d	B	Mean	S^2d	B	Mean	S^2d	B	Mean	S^2d	B	Mean	S^2d	B	Mean	
57.266	-0.498	135.250	-228.503	1.085	68.767	2.000	0.263	10.017	6.690	1.863	19.222	61.573*	-0.361	77.169	1
1,760.286	0.774	176.383	0.700	0.110	81.883	0.418	0.172	9.333	13.604	0.978	28.053	-1.334	2.227	88.491	2
-467.204	1.649	215.517	-184.832	0.904	101.400	0.240	0.166	9.317	-5.010	1.221	29.360	8.926	1.965	79.122	3
-330.034	0.484	152.225	1,860.989**	0.564	79.642	1.174	0.398	7.550	83.231**	1.241	21.743	18.269	1.307	63.942	4
-713.430	1.004	196.783	709.447**	0.467	120.825	-0.454	-0.134	9.192	8.636	0.446	34.983	-3.083	1.212	80.186	5
-436.538	0.155	200.351	-49.349	0.044	76.508	-0.160	0.358	10.000	7.406	-0.026	24.583	22.980	-0.128	81.458	6
1,693.755	1.636	184.067	470.990**	1.457	84.500	0.451	1.859	8.938	57.414*	1.283	26.622	30.991	-0.170	71.603	7
226.860	1.448	167.008	-189.307	2.617	95.667	-0.106	2.448	9.736	-2.427	2.084	28.855	21.446	0.070	81.091	8
-165.874	1.029	134.725	713.247**	0.647	78.417	-0.002	3.150	7.300	6.317	0.154	26.043	36.403	0.235	89.453	9
1,061.410	1.761	171.417	87.481*	0.383	96.767	3.126	0.638	8.792	3.305	-1.057	28.053	55.634*	0.894	63.533	10
4,877.604	1.195	170.008	251.922*	0.689	105.625	-0.139	0.555	9.458	42.142	0.350	32.152	97.552**	1.559	99.244	11
-142.411	0.507	181.833	-196.195	1.675	133.958	-0.473	1.364	10.719	-6.521	1.583	35.263	74.610**	2.081	82.328	12
2,186.286	1.855	121.331	-110.832	2.358	142.000	1.950	1.762	10.358	-6.484	2.879	34.338	65.557*	2.109	99.119	13
	1.558			0.640			1.095			0.702			0.555		SE(BI)

*Significant at the probability level (5%). ** Significant at the probability level (1%).

Table (4) Analysis of variance for stability (Elberhert and Russel Model).

S.O.V.	D.F	Mean squares				
		1	2	3	4	5
Variety	**12**	124.575**	32.403*	0.934*	441.715*	1,176.000*
Environment	**3**	623.277**	200.961**	4.295**	5,042.351**	2,810.117*
Var.x Envi	**36**	76.917*	32.879**	1.202*	600.014*	1,242.685*
Env.+ vari.xEnv	**39**	118.945	45.808	1.440	941.732	1,363.257
Linear (Envi)	**1**	1,869.831**	602.884**	12.884**	15,127.054**	8,430.350**
Envi x var.(lin.)	**12**	134.759**	49.111**	1.031*	767.858*	318.511*
Pooled deviation	**26**	44.304**	22.858**	1.188**	476.392**	1,573.636*
Pool error	**96**	19.945	20.505	1.713	705.540	2,503.682
Total	**51**					

Regression coefficient attributes

As for the regression coefficient Reg coefficient (b), it was positive and negative between thevarieties, as it appears from Table (5) that the regression coefficient for plant height was between positive and negative, and the highest positive value was for variety No. 2, which amounted to 2.227, and the lowest negative value was for genotype.

Table (5) Reg coefficient (b).

Variety	Reg coefficient				
	Plant height	No. of pods/plant	Pod length	No. of seeds/plant	Dry seeds yield/plant
1	-0.361	1.863	0.263	1.085	-0.498
2	2.227	0.978	0.172	0.110	0.774
3	1.965	1.221	0.166	0.904	1.649
4	1.307	1.241	0.398	0.564	0.484
5	1.212	0.446	-0.134	0.467	1.004
6	-0.128	-0.026	0.358	0.044	0.155
7	-0.170	1.283	1.859	1.457	1.636
8	0.070	2.084	2.448	2.617	1.448
9	0.235	0.154	3.150	0.647	1.029
10	0.894	-1.057	0.638	0.383	1.761
11	1.559	0.350	0.555	0.689	1.195
12	2.081	1.583	1.364	1.675	0.507
13	1.109	2.879	1.762	2.358	1.855

The genotype1 which amounted to -0.361. As for the number of pods plant-1, the regression coefficient was positive in value, but negative only for genotypes 6 and 10, and its value reached -0.026 and -1.057, respectively. It was also positive for all genotype for the pod length trait, except for genotype 5, which was negative and amounted to -0.134. As for the number of seeds plant^{-1}, the regression coefficient was positive for all genotypes, and the highest positive slope was for genotype13, amounting to 2.358, and its lowest value was at half-poi 6, amounting to 0.044. As for the seedcharacteristics of each plant, it appears from the same table that the regression coefficient was positive for all genotypes except for genotype 1, which appeared with a negative value and amountedto -0.498.

It is clear from Table (6) there is a significant effect of the interaction between the genotypes and the environment on the studied traits of the Faba bean genetic compositions at a probability level of 5% for Duncan's multiple range test it is clear that the genotype (10) was significantly superior to the rest of the compositions in the trait of plant length (cm) which record (89.360 cm) and the lowest length resulted from the genotype (1), while the genotype (6) was significantly superior to the rest of the trait of the number of pods plant^{-1} and the lowest number came from the genotype (3) which arrive 23.753, and there was no significant differences appeared for the trait of pod length as a result of the effect of the two-way interaction between the genotypes and the environment. As for the traitof the number of seeds plant^{-1}, it varied significantly between the genotypes as a result of their beingaffected by the environment. The genotype (4) achieved the highest number of seeds plant^{-1} in this respect, reaching 112,583 seeds, and the lowest number in this trait was for the genotype (3), whichputted (79,417). As for the trait of the dry seed yield plant^{-1}, the genotype (5) outperformed the restof the compositions in this trait and achieved the highest yield of grams plant^{-1}, show up 202,458 grams plant^{-1}, and the lowest yield was for the genotype (13), was recorded 145,028 grams.

Table (6) Environment (Linear) and variety x environment (linear) against deviation.

Variety	Traits				
	Plant height(cm)	No. of pods/plant	Pod length (cm)	No of seeds /plant	Dry seeds yield/plant(g)
1	69.061	24.622	8.583	84.542	149.825
2	78.533	25.768	9.213	85.708	165.775
3	80.373	23.753	9.608	79.417	150.458
4	83.803	29.313	9.325	112.683	177.825
5	87.988	32.568	9.575	106.092	202.458
6	82.541	33.372	9.736	96.108	160.025
7	85.686	27.736	9.142	88.783	167.475
8	84.194	29.955	8.825	110.367	185.875
9	81.972	29.232	9.353	94.658	184.383
10	89.360	27.694	9.758	99.042	163.576
11	81.174	26.219	10.083	99.792	188.862
12	78.692	29.816	9.108	100.317	165.333
13	73.361	29.222	8.400	108.450	145.028

DISCUSSION

Through the analysis of variance table for the sum of the averages of the traits of the genotypes, it appeared that the genotypes varied significantly among themselves in the studied traits. This result may be affected by the effect of the genetic factors carried by each genotype which different from one structure to another, in addition to the difference in the extent of the suitability of the genotypes and their response to the prevailing environmental conditions in the area of implementation of the study. These responses are due to the type and location of the gene on the chromosome, which may express itself by its effect on a trait. This result is consistent with what was mentioned by each of [2, 3 5, 8, 9,19, 22, 26, 36, 37and 39], for the traits of number of seed pod^{-1}, plant height, number of branches plant^{-1}, and total seeds yield. the presence of variation is important to study the genetic behavior of these traits in order to improved them in breeding program in future.

The results of the stability parameters in the Faba bean, the genetic compositions under study show that they varied among themselves in the trait of plant height, seed yield and number of pods for the S2D parameter. Also, there appeared different significant effects of the effect of the analysis of the genetic stability of the compositions as a result of the interaction between the genetic compositions and the environmental line (the environmental conditions prevailing in the study area), i.e., the effect of genetic interaction with the environment on the induction of these genetic compositions. Also, the

regression coefficient study for the traits of the genetic compositions varied between positive and negative values under these environmental conditions. The differences in stability reflect the interactions of their genetic base with the environments that select and distinguish the genotypes from each other. Stability methods are important in determination the stable genotypes which resist change their traits in different environments and regard as phenotypic and genotypic stable. These results were similar with what founded by which of (10, 12, 17, 19, 21, 28 and 41].

The change in environmental conditions had a significant positive effect on the stability of these genotypes. Agricultural productivity is highly affected by climatic change in terms of fluctuations in temperatures, precipitation, and extreme weather events, as well as variability in seasonality.

At present, sustainable agriculture is threatened by climate change, these results were agreed with [12, 16, 24; 27, 30, 33, 35 and 41], whom indicated in their research's that environmental conditions play a major role in the physiological effects on metabolic processes in plants and may also affect the genetic expression of these traits. Thus, breeding adaptive traits is required to increase the resilience to broad-spectrum stresses and maintain productivity, food security, and agricultural sustainability. At the same time, the demand for environmentally friendly crops and for food security has increased and has led to the establishment of cropping systems that include annual grain legumes.

CONCLUSION

In conclusion, the findings of this study highlight promising Faba bean genotypes, particularly 4 and 11, that demonstrate high yield potential and stability across diverse environmental conditions, making them advantageous for sustainable agricultural practices. Selecting the appropriate genotypes based on their performance in specific traits can enhance both stability and yield in Faba bean production. These identified genotypes not only serve as strong candidates for further breeding efforts but also contribute to the overall goal of improving Faba bean production sustainability.

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