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(Original Article)

Evaluation of Genetic Variability of Faba Bean (*Vicia faba* L.) Genotypes under Different Environments

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Abstract

This study is an attempt to evaluate twenty-two of faba bean genotypes under two locations i.e., Al-Matana and Al-Marashda during 2018-2019 and 2019-2020 seasons. The results revealed that separate and combined analyses over years as well as years/locations were significant among genotypes for all studied traits. Moreover, combined means showed the highest genotypes resulted from planting in Al-Matana compared to Al-Marashda locations for all studied traits. Also, the combined means for number of seeds/plant indicated that the highest mean values in rank were recoded for genotypes no.4 (147.60), no.6 (144.28) and no.9 (142.33) at Al-Matana and no.8 (49.20), no. 9 (48.67) and no.12 (45.00) at Al-Marashda. The highest mean values of seeds yield/plant, i.e., 127.33, 113.20 and 107.07 g were recorded from genotypes no. 9, 4 and 16 at Al-Matana location. Likewise, 100-seed weight ranged from 71.33 to 94.86 with an average of 79.37 and from 71.01 to 92.08 with an average of 79.64 g under Al-Matana and Al-Marashda locations, respectively. The reduction % in number of seeds/plant caused by Al-Marashda condition was very high and larger than Al-Matana condition and reached to 58.40, 72.75 and 61.19 in the first, second years and combined data, respectively. The stress susceptibility showed that 14 faba bean genotypes were susceptible to the stress and considered susceptible to Al-Marashda location, but the other 8 genotypes considered to be tolerant. Ten genotypes concern seed yield/plant trait showed highest susceptible index. These genotypes could be considered to be susceptible under Al-Marashda condition, but the other 12 genotypes could be considered tolerant to Al-Marashda condition. The slight discrepancy between (PCV) and (GCV) caused high and unreliable estimates of each of broad sense heritability and genetic advance from selection for all studied traits. Broad sense heritability estimates ranged from 0.97 to 0.98 across all studied traits.

Keywords: *Faba Bean, Genetic variability, Genotypes, Heritability, Genetic advance*

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Introduction

Faba bean (*Vicia faba* L.) is one of the most leguminous crops, especially in Egypt and many developing countries. It is considered as a low- coast source of protein. Faba bean intrinsically fixes atmospheric nitrogen into the soil through symbiotic association in the root nodules with soil bacteria (*Rhizobia leguminosarum* frank). In Egypt, the cultivated area of faba bean in the eighties of the last century exceeded 360000 faddan, which has decreased gradually until reached 125000 faddan during 2020-2021 season. There are many reasons that explain the decline in the proportion of faba bean in Egypt. The most important of which is the limited area that can be cultivated in the Nail valley and the competing with other winter crops. Therefore, it was important to expand the area faba bean in newly reclaimed lands which, may contain a percentage of salt in water irrigation. Faba bean is often grown on saline soils in Egypt. Sharma (1995) proved that the susceptibility of faba bean to salinity restricts or even prevents its cultivation in newly reclaimed area in which the use of saline water or even diluted sea water are the only source of irrigation available. Tadesse *et al*. (2011) in Egypt, noted that the newly reclaimed soil affects faba bean production and selection to salt-tolerant genotypes capable of surviving under salinity stress is very important for breeders. Therefore, the tendency to develop a new variety that have the ability to withstand stress conditions resulting from salinity of soil and irrigation water is of great importance goal. Some of researchers studied drought indices in legumes such as Link *et al.* (1999) who evaluated some faba bean genotypes and indicated highly significant variances between genotypes for drought tolerance. Ouji *et al.* (2017) evaluated four Tunisian faba bean genotypes and identified relatively drought tolerant genotype by drought susceptibility index. Siddiqui *et al.* (2015) evaluated 10 faba bean genotypes under drought stress condition and found genotypes C5 and Zafar 1 were relatively tolerant to drought stress. Desoky *et al.* (2020) indicated that the verities *i.e.,* Nubaria-2, Giza-843 and Sakha-3 were the more tolerant to drought stress than Giza716 and Sakha-4. The objectives of the current study are evaluation the performance of 22 genotypes of faba bean under old soil and newly reclaimed one in Upper Egypt for yield and yield components and estimate the phenotypic and genotypic coefficients of variation, genetic advance and heritability in brad sense.

Materials and Methods

A field experiment was carried out at two different locations *i.e.,* Al-Matana and Al-Marashda stations belong to Agricultural Research Center (ARC), Egypt, during 2018-2019 and 2019-2020 seasons to evaluate twenty-two faba bean genotypes. Soil analysis of experimental sites was presented in Tables 1 and 2 as well as water analysis was presented in Table 3. The genetic materials used in this study included twenty-two faba bean genotypes, nineteen of them were breeding lines (1-19) while the other three genotypes (20-22) were commercial located cultivars *i.e.,* Misr 1, Wady 1 and Giza 843. All these genotypes were developed by the Legume Crops Research Section, Agricultural

Research Center, Egypt. The name and pedigree of all studied faba bean genotypes were presented in Table 4.

Table 1. Some of the physical and chemical properties of the experimental soil site of Al-Marashda

Texture class	Particle size distribution			$CaCO_3$ %	EC (dSm^{-1}) (1 : 2.5)	pH (1-5)
	Sand %	Silt %	Clay %			
Sandy	81.3	12.7	6.0	12.55	3.01	8.08

Cation (meq L^{-1})				Anion (meq L^{-1})			
Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
30.02	0.88	12.0	6.2	0.0	0.82	30.6	17.9

Table 2. Physical and chemical analysis of the experiment soil for Al-Matana region

Physical properties	**Sand %**	18.00
	Silt %	37.40
	Clay %	44.60
Soil texture		Clay loam
Chemical properties	**Organic Matter %**	1.90
	H CO_3 (meq/100 g soil)	0.80
	SO^{--}_4 (meq/100 g soil)	3.83
	Soil pH	6.80
	E.C. (mm hose/cm)	1.49
	Ca CO_3%	2.34

Table 3. Water analysis of the irrigation water used for the experimental site of Al-Marashda

TDS	pH	EC(dSm^{-1})	Soluble cations (mg/l.)				Soluble anions (mg/l.)			
mg/l	(1 : 5)	(1 : 2.5)	Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	$SO4^{--}$	CL^-
225.5	7.3	3.25	28.5	8.8	31.6	6.2	24.7	110.5	41.6	31.2

Table 4. The pedigree of the studied genotypes

Genotype	Pedigree	Genotype	Pedigree
1	Giza716 x Giza2	12	Sakha1x Giza843
2	Giza716 x Giza2	13	Sakha1x Giza716
3	Giza716 x Giza2	14	Sakha1x Giza716
4	Giza716 x Giza2	15	Sakha1x Giza716
5	Treble white x Giza716	16	Sakha1x Giza716
6	Treble white x Giza716	17	Treble white x Giza843
7	Treble white x Giza716	18	Treble white x Giza843
8	Giza843 x Treble white	19	Treble white x Giza843
9	Giza843 x Treble white	20(Wady 1)	Giza blanka × Treble white
10	Sakha1 x Giza843	21(Misr 1)	Giza 3 ×123A/45/76
11	Sakha1 x Giza843	22(Giza-843)	85/2076/561× 461/845/83

All faba bean genotypes were sown at the two locations in both seasons in a randomized complete block design with three replications. Each plot consisted of three rows, 3-meter long, 60 cm width and 25 cm between hills within row to give 12 hills/ row and thinned at one plant per hill. The plot area is a 5.4 m^2 (3 * 1.8 m). The plots were kept weeds by hand weeding. The sowing of seeds was conducted on 1 December 2018 and 2019 in both of Al-Marashda and Al-Matana stations by hands. Irrigation at Al-Matana site was by the surface irrigation

system using of the water of the Nile River, while it was by drip irrigation system with ground water at Al-Marashda site. Other recommended cultural practices for faba bean crop adapted through the growing seasons to raise good crops. Data on different agronomic traits were collected on a random sample of five guard plants, on plot and plant basis. Number of seeds per plant, seed weight/plant, 100- seeds weight and seed yield/plot, were estimated on plot basis.

Statistical Analysis

A regular analysis of variance of RCBD were analyzed for each experiment in each year and over the two years as outlined by Cochran and Cox (1957).

Genetic and phenotypic coefficients of variation

Genotypic (G.C.V.) and phenotypic (P.C.V.) coefficients of variability were calculated according to Burton (1952) as follows:

$$G.C.V. = \frac{\sqrt{\sigma^2_g}}{\overline{X}} \times 100 \quad , \quad P.C.V. = \frac{\sqrt{\sigma^2_p}}{\overline{X}} \times 100$$

Where $\overline{X}$ = The general mean, σ^2_g = genotypic variance, σ^2_p phenotypic variance.

Broad sense heritability estimate

Broad sense heritability was calculated according to Allard (1960) as:

$$H = \{\sigma^2_g / (\sigma^2_e + \sigma^2_g)\} \times 100$$

Where, H = Broad sense heritability, σ^2_g and σ^2_e is genotypic and error variance, respectively.

$$GA = K \times h^2 \times \sigma_p.$$

Where GA (genetic advance), k (the selection differential) and at 5% selection intensity, h^2 (broad sense heritability), σ_p (phenotypic standard deviation) as suggested by Johanson *et al.* (1955).

Drought susceptibility index

Stress susceptibility index was calculated as outlined by Fischer and Maurer (1978).

Yield of individual genotypes was determining under stress (Y_1) refer to Al-Marashda location and favorable (Y_e) refer to Al-Matana location. Average yield of all genotypes under Al-Marashda (x_1) and Al-Matana conditions (x_e) were used to calculate stress intensity (s) as: $D = 1 - x_1 / x_e$

The mean stress susceptibility index (S) of individual genotypes calculates as: $S = 1-(Y_1/Y_e) / D$

Genotypes with average susceptibility or resistance to stress have “S " values less than 1.0 indicate to less susceptibility and great resistance to silently

stress and the drip irrigation system. Meanwhile, a value of S= 0.0 indicate maximum possible stress resistance (no effect of stress on yield).

Results and Discussions

Mean squares of all studied traits of faba bean crop in two locations (Al-Matana & Al-Marashda) during the two seasons were presented in Table 5.

Table 5. Mean squares of faba bean characters from the two locations of the two seasons

Source of variance	d.f.	No. of seeds /plant		Seeds yield / pant, g		Weight of 100 seeds, g		Seeds yield /plot, kg	
		Year1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
AL-MARASHDA									
Rep.	3	69.77	81.79	50.28	41.25	0.48	6.48	0.002	0.04
Genotypes	21	295.78**	206.38**	271.7**	182.7**	281.1**	199.0**	0.04**	0.09**
Error	42	21.76	26.83	10.97	16.47	13.32	9.46	0.004	0.003
AL–MATANA									
Rep.	3	52.6	153.1	29.74	72.7	2.43	9.91	0.05	0.02
Genotypes	21	1565.4**	2352.8**	952.57**	1637.1**	575.5**	369.8**	0.52**	0.69**
Error	42	82.7	97.0	45.45	52.7	4.41	10.4	0.045	0.04

*, ** Significant at 0.05 and 0.01 levels of probability, respectively. d.f.: degree of freedom.

The results indicated significant differences among the genotypes for all studied traits during the two seasons in separate analysis under Al-Matana and Al-Marashda locations. Moreover, the combined analysis of variance over seasons showed significant differences among genotypes for all studied traits in the two locations (Tables 6 and 7).

Table 6. Combine analysis of variance for the studied traits over two years in Al-Marashda

Source of variance	d.f.	No. of seeds /plant	Seeds yield / plant, g	100- seed weight, g	Seeds yield / plot, kg
Years	1	2362.20**	2013.18**	304.55 **	0.08
Rep.(Year)	4	75.78**	45.77**	3.392	0.03
Genotypes	21	305.99 **	310.62 **	361.10 **	0.08**
Gen. × Years	21	196.16 **	143.84 **	118.69**	0.05**
Error	84	24.29	13.732	11.372	0.01

*, ** Significant at 0.05 and 0.01 levels of probability, respectively. d.f.: degree of freedom.

Table 7. Combine analysis of variance for the studied traits over two years in Al-Matana

Source of variance	d.f.	No. seeds /plant	Seeds yield / plant, g	100- seed weight, g	Seed yield / plot, kg
Years	1	13108.20**	7379.30**	48.49**	0.24**
Rep.(Year)	4	102.80	51.20	6.15	0.03
Genotypes	21	3033.60**	1997.00**	455.19**	0.89**
Gen. × Years	21	884.60**	592.70**	190.14**	0.33**
Error	84	89.90	49.10	7.42	0.04

*, ** Significant at 0.05 and 0.01 levels of probability, respectively. d.f.: degree of freedom.

This finding suggested adequate amount of genetic variability among genotypes that may be helpful for yield improvement by selection. In addition, the combined analysis over/ locations, showed highly significant differences in most characters, (Table 8).

Table 8. Combined analysis of variance for the studied traits over years and locations

Source of variance	d.f.	No. of seeds /plant	Seeds yield / plant, g	100- seed weight, g	Seeds yield / plot, kg
Location	1	340188.40**	207197.26**	4.30	833.61**
Rep.(L)	4	114.71	58.71	5.23	0.02
Years	1	2170.64**	841.91**	297.44**	0.29**
Location (Y)	1	13299.72**	8550.59**	55.26*	0.02
Rep. (YL)	4	63.90	38.26	4.42	0.04
Gen.	21	1879.47**	1377.68**	526.69**	0.64*
Loc. x Genotypes.	21	1460.09**	929.91**	289.73**	0.33**
Years x Genotypes.	21	491.01**	282.86**	150.49**	0.23**
Loc. x Yea. X Gen.	21	589.77**	453.70**	158.40**	0.16**
Error	168	57.33	31.39	9.40	0.02

*, ** Significant at 0.05 and 0.01 levels of probability, respectively. d.f.: degree of freedom.

Furthermore, the interaction of genotypes*years under Al-Marashda (Table 8) and Al-Matana locations as well as the interaction in combined over/locations between genotypes*years*location were significant, indicating that, the different between traits were unstable from year to year either under Al-Matana or under Al-Marashda conditions (Table 8). Bakheit and Mahdy (1988) showed that the interaction between accessions and years were significant for seed yield/plant, seeds/pod and 100- seed weight. Also, the phenotypic coefficient of variation was higher than the genotypic one for all the characters, except number of seeds/pods. Link *et al.* (1999) and Bakhiet *et al.* (2015) indicated highly significant variances between genotypes. These results agreement with those reported by Link *et al.* (1999), Abdel-Rahman *et al.* (2019) and El-Shal and Azza El-Sayed (2019).

Number of seeds /plants

The highest mean values of number of seeds/ plant trait of *V. faba* recorded with the genotypes grown in Al-Matana compared to Al-Marashda locations in both of two seasons as shown in Table 9. However, the highest mean values of number of seeds/plant recorded for genotypes no.9 (147.00), no.4 (138.37) and no.13 (127.53) with an average of 98.46 at Al-Matana and no.9 (60.67), no.13 (55.33) and no.12(53.33) with an average of 40.96 at Al-Marashda in first season. The 2nd season showed the same trend, where the highest mean values recorded for the genotypes no.12 (167.33), no.6 (163.00), and no.17 (159.33) with an average of 118.35 at Al-Matana and no.8 (49.00), no.3 (44.33) and no.1 (44.13) and with an average of 32.49 at Al-Marashda, respectively.

Table 9. Means of seeds number / plant, reduction% and stress susceptibility index (s) of the 22 faba bean genotypes

Genotypes	No. of seeds /plant								
	Year 1			Year 2			Combined		
	Matana	Marashda	S	Matana	Marashda	S	Matana	Marashda	S
1	101.90	40.00	1.04	125.00	44.13	0.89	113.45	42.07	1.03
2	112.33	41.33	1.08	104.33	37.00	0.89	108.33	39.17	1.04
3	78.67	39.67	0.85	96.67	44.33	0.75	87.67	42.00	0.85
4	138.87	47.33	1.13	156.33	19.67	1.20	147.60	33.50	1.26
5	65.33	22.67	1.12	127.67	20.33	1.16	96.50	21.50	1.27
6	125.57	38.67	1.19	163.00	29.67	1.13	144.28	34.17	1.25
7	97.00	27.60	1.23	85.33	36.00	0.80	91.17	31.80	1.06
8	99.67	49.40	0.86	114.00	49.00	0.79	106.83	49.20	0.88
9	147.00	60.67	1.01	137.67	36.67	1.01	142.33	48.67	1.08
10	74.00	41.00	0.76	73.00	26.00	0.89	73.50	33.50	0.89
11	91.33	52.33	0.73	122.33	28.00	1.06	101.33	40.17	0.99
12	104.93	53.33	0.84	167.33	36.67	1.08	136.13	45.00	1.09
13	127.53	55.33	0.97	139.67	25.67	1.12	133.6	40.50	1.14
14	68.00	49.33	0.47	130.33	34.33	1.01	99.17	41.83	0.94
15	81.00	42.67	0.81	95.67	25.33	1.01	88.33	34.00	1.01
16	127.00	34.33	1.25	137.33	24.33	1.13	132.27	29.33	1.27
17	93.57	37.33	1.03	159.33	33.00	1.09	126.45	35.17	1.18
18	74.33	41.00	0.77	96.67	36.33	0.86	85.50	38.67	0.89
19	91.33	27.00	1.21	110.33	18.43	1.15	100.83	22.72	1.27
20	93.60	35.67	1.06	81.50	38.00	0.74	87.55	36.83	0.95
21	85.33	27.03	1.17	96.20	33.67	0.90	90.77	30.35	1.09
22	87.80	37.33	0.98	94.03	38.33	0.82	87.55	37.83	0.93
Means	98.464	40.96		118.35	32.49		108.41	42.07	
Red. %	58.40			72.75			61.19		
LSD 5%	15.17	7.69		16.17	8.54		10.29	6.2	
LSD 1%	20.30	10.29		21.64	11.43		13.75	8.28	

On the other hand, the combined means indicated that the highest values recoded for genotypes no.4 (147.60), no.6 (144.28) and no. 9 (142.33) with an average of 108.41 at Al-Matana and no.8 (49.20), no. 9 (48.67) and no.12 (45.00) with an average of 42.07 at Al-Marashda, respectively. Hence this suggested adequate amount of genetic variability among genotypes that for number of seeds /plants may be helpful for yield improvement by selection. At all, the combined data revealed that the highest genotypes resulted from planting in Al-Matana compared to Al-Marashda locations.

The reduction% in number of seeds/plant caused by Al-Marashda condition was very high and larger than in seed yield /plant, and reached to 58.40, 72.75 and 61.19 in the first, second seasons and combined data, respectively; reflecting the effect of varying environments among locations besides the differential response of genotypes in these environments. Furthermore, location had the major effect on the relative genotypic potential of these traits Abdel-Rahman *et al.* (2019) indicated that the G.42 recorded the highest values for no. of seeds/ plant and seed weight/plant at Sids location, whereas, G49 and G40 recorded the heaviest 100 seed weight at Sids location. Payman, (2017) found that the Italy variety recorded high rate in increasing grain length (3.07 cm), however Turkish variety inscribe maximum value for each of seed number/pod and yield/ plant

(5.67 and 0.715kg, respectively), while Duhok variety has significant effect for 100 seed/plant (0.367 g).

These results agree with those reported by Ulukan *et al.* (2003) and Peyman *et al.* (2019). The stress susceptibility index of the different genotypes of combined date showed that 14 faba bean genotypes were susceptible to the stress and susceptibility index(s) more than unity and considered susceptible to Al-Marashda location. But the other 8 genotypes considered tolerant to that condition. Siddiqui *et al.,* (2015) and Sánchez *et al.,* (2020) found that the genotypes C5 and Zafar 1 were relatively tolerant genotypes to drought stress. Moreover, the selecting adapted genotypes under environmental stress conditions helps to improve adaptation and stress tolerance in cultivars.

Table 10. Means of seeds yield / plant, reduction% and stress susceptibility index (s) of the 22 faba bean genotypes

Genotypes	Seeds yield / plant, g								
	Year 1			Year 2			Combined		
	Matana	Marashda	S	Matana	Marashda	S	Matana	Marashda	S
1	94.27	37.00	1.062	114.33	40.13	0.89	104.30	38.57	0.96
2	79.93	39.67	0.881	84.33	32.67	0.84	82.13	36.17	0.85
3	67.67	36.67	0.801	56.67	42.20	0.35	62.17	38.43	0.58
4	102.40	34.33	1.162	124.00	14.00	1.22	113.20	24.17	1.19
5	52.33	20.40	1.067	105.33	17.00	1.16	78.83	18.70	1.16
6	93.83	27.00	1.245	119.00	19.80	1.15	106.42	23.40	1.18
7	92.00	18.87	1.390	80.00	26.67	0.92	86.00	22.77	1.12
8	71.00	42.20	0.709	108.00	37.67	0.90	89.50	39.93	0.84
9	116.33	52.40	0.961	138.33	33.33	1.05	127.33	42.87	1.01
10	71.33	36.33	0.858	68.33	21.67	0.94	69.83	29.00	0.89
11	74.00	44.00	0.709	91.00	20.67	1.06	82.50	32.33	0.92
12	76.50	50.10	0.603	127.67	25.07	1.11	102.08	37.58	0.96
13	90.93	43.80	0.906	104.67	20.17	1.11	97.80	31.98	1.02
14	50.00	34.33	0.548	90.00	26.23	0.98	70.00	30.28	0.86
15	75.00	30.37	1.040	70.00	18.13	1.02	72,50	24.25	1.01
16	100.80	25.5	1.306	113.33	20.00	1.13	107.07	22.75	1.20
17	60.83	25.73	1.009	91.33	27.07	0.97	76.08	26.40	0.99
18	55.33	32.6	0.718	72.00	28.30	0.84	63.67	30.45	0.79
19	70.87	24.83	1.136	78.67	14.00	1.13	74.77	19.42	1.12
20	89.17	28.77	1.184	65.97	24.67	0.86	77.57	26.72	0.99
21	54.73	18.10	1.170	63.53	21.97	0.90	59.13	20.03	1.00
22	76.43	30.23	1.057	77.77	32.00	0.81	77.10	31.12	0.90
Means	77.99	33.33		92.92	25.52		85.45	29.42	
Red. %	57.26			57.26			65.57		
LSD 5%	11.12	5.46		11.94	6.70		7.1	4.52	
LSD 1%	14.88	7.31		15.98	8.96		9.49	6.04	

Seed yield/plant

Mean of seed yield /plant as show in Table 10 indicated that all the genotypes fluctuated from one location to another. The highest yielding ability values of seed yield/ plant of faba bean were recorded with the genotypes which grown in Al-Matana compared to Al-Marashda locations in the 1st and 2nd seasons. However, the highest mean values 102.40, 116.33, and 100.80 g. with an average of 77.99 g/plant were recorded in the 1st season at Al-Matana location for genotypes no. 4, 9 and 13, respectively. In the 2nd season the highest means values, 124.0 g, 138.33 and 127.67, with an average of 92.92 g/plant recorded for genotypes no. 4, 9 and 12 at Al-Matana and 42.20, 40.13 and 37.67 g with an

average of 25.52 g/plant resulted from the genotypes no. 3, 1 and 8 at Al-Marashda location, respectively. On other hand, the combined ranged from 63.67 to 127.33 with an average of 85.45 g/plant under Al-Matana and from 18.70 to 42.87 with an average of 29.42 g/plant under Al-Marashda location. The results indicate that the highest mean values as 127.33, 113.20 and 107.07 g/plant were recorded for genotypes no. 9, 4 and 16 at Al-Matana location.

Generally, the results of combined means showed the highest genotypes in seed yield/plant were planting in Al-Matana compared to Al-Marashda location. Hence, Al-Marashda conditions caused severe reduction in seed yield/plant reached 57.26, 57.26 and 65.57% in the first, second seasons and combined data, respectively, Reflecting the effect of varying environments among locations besides the differential response of genotypes in these environments. Furthermore, location had the major effect on the relative genotypic potential of these traits. Abdel-Rahman *et al.* (2019) found that the G.42 recorded the highest values for no. of seeds/ plant and seed weight/plant at Sids location. Also, Karaadvut *et al*. (2010) the highest grain yield/ plant was obtained from cultivar Erase 87 (3.21 t ha^{-1}) across environments. Both these attributes were responsive to changing environments and could be recommended for favorable trend (Sharifi *et al.,* 2021).

In dry land condition, the lowest value of seed yield (473.3 kg/ha) was obtained in genotype G6, which decreased by 74.4% compared to supplemental irrigation. The genotypes G2 and G8 had the highest seed yield and their yield reduction were 43.7 and 46.1% than supplementary irrigation, respectively. Nouri *et al.,* (2011), Payman, (2017) and Sharifi *et al.,* (2021) obtained the same results. Our results of stress susceptibility index (s) for 22 genotypes revealed that 10 out of them showed that highest susceptible index (s) in the combined date for seed yield/plant and susceptibility index was more than unity. These genotypes were no. 4, 5, 6, 7, 9, 13, 15, 16, 19 and 21. These genotypes could be considered susceptible, but the other 12 genotypes could be considered tolerant condition. It should be indicated that, the highest yielding genotypes no.1 and no.6 were tolerant to Al-Marashda location and scored stress susceptibility index less than unity. Siddiqui *et al.,* (2015) found genotypes C5 and Zafar 1 are relatively tolerant genotypes to drought stress. Desoky *et al.,* (2020) indicated that the varieties i.e., Nubaria-2, Giza-843, and Sakha-3 were the more tolerant to drought stress than Giza716 and Sakha-4.

Hundred - Seed weight

The highest mean values of 100- seeds weight of faba bean in first season were recorded with the genotypes grown in Al-Marashda compared to Al-Matana locations. This result revealed to be opposite to other results obtained from other studied traits (Table 11) at overall average. However, the highest mean values of 100-seeds weight recorded for genotypes no.10 (95.93), no. 20 (95.27) and no.7 (93.27), with an average of 79.98 g at Al-Matana. While the opposite results at Al-Marashda location showed that the genotypes no. 2 (95.90), no.12 (93.33) and no.1 (92.53 with an average of 81.16 g in first season. In the second season, same

trend was found as obvious first season. On the other hand, combined means ranged 61.28 to 94.86 with an average of 79.37 and from 66.05 to 92.08 with an average of 79.64 g under Al-Matana and Al-Marashda locations, respectively.

Table 11. Means of 100 - seeds weight, reduction% and stress susceptibility index (s) of the 22 faba bean genotypes.

Genotypes	100 Seed weight, g								
	Year 1			Year 2			Combined		
	Matana	Marashda	S	Mataana	Marashda	S	Matana	Marashda	S
1	92.63	92.53	-0.08	91.43	91.23	0.26	92.03	91.87	0.58
2	71.23	95.90	23.40	80.83	88.27	-10.70	76.04	92.08	-70.31
3	86.03	92.50	5.08	58.40	90.70	-64.31	72.23	91.60	-89.39
4	79.63	72.53	-6.03	79.33	73.23	8.95	79.48	72.88	27.68
5	80.17	90.10	8.37	82.43	83.37	-1.32	81.31	86.72	-22.18
6	75.00	69.93	-4.57	73.07	66.73	10.08	74.05	68.32	25.79
7	93.27	68.40	-18.01	93.57	73.63	24.78	93.40	71.01	79.91
8	71.27	85.57	13.56	94.80	77.00	21.83	83.02	81.28	6.99
9	79.13	86.40	6.20	98.30	90.93	8.72	88.7	88.68	0.08
10	95.93	88.73	-5.07	93.77	83.63	12.57	94.86	86.18	30.50
11	81.07	85.83	3.97	81.73	73.47	11.76	81.39	79.64	7.17
12	72.83	93.93	19.57	76.50	68.40	12.31	74.66	81.18	-29.11
13	71.30	79.30	7.58	74.90	78.57	-5.70	73.11	78.92	-26.49
14	73.53	69.30	-3.89	69.10	76.53	-12.50	71.33	72.91	-7.38
15	92.73	71.20	-15.69	73.17	71.43	2.76	82.94	71.32	46.70
16	80.77	74.13	-5.55	82.43	82.23	0.29	81.61	78.18	14.01
17	65.00	68.97	4.13	57.57	81.90	-49.15	61.28	75.43	-76.97
18	74.43	79.60	4.69	74.43	77.87	-5.37	74.44	78.72	-19.17
19	77.37	91.83	12.63	71.23	75.83	-7.50	74.31	83.82	-42.66
20	95.27	80.70	-10.33	76.20	65.20	16.79	85.75	72.93	49.83
21	64.23	66.97	2.88	66.13	65.17	1.69	65.17	66.05	-4.50
22	86.73	81.07	-4.41	83.57	83.27	0.41	85.15	82.16	11.70
Means	79.98	81.16		78.77	78.12		79.37	79.64	
Red. %	-1.48			0.82			-0.34		
LSD 5%	3.47	6.018		5.32	5.06		3.16	3.74	
LSD 1%	4.67	8.05		7.12	6.78		4.22	5.00	

Generally, the combined data revealed that the highest means recorded for genotypes no.1 (92.3), no. 7 (93.4) and no. 10 (94.86) at Al-Matana and no.1 (91.87), no.2 (92.08) and no.3 (91.60) g at Al-Marashda locations. The reduction % was -1.48, 0.82 and -0.34 in the first, second seasons and combined means. This result could be due to that 100- seeds weight is an estimated character (as weight of seeds) and it was more affected than seed yield/plant by Al-Marashda conditions as mentioned before for seed yield/plant and number of seeds/ Plant. Therefore, the stress susceptibility index become of no meaning. Abdel-Rahman *et al*. (2019) reported that the G.42 recorded the highest value for seed weight/plant in spite of G49 and G40 recorded the heaviest 100 seed weight at Sids location. Also, Payman (2017) found that Duhok variety has significant effect for 100- seed/plant (0.367 g) under different locations. These results were in agreement with those obtained by Mona *et al.* (2018).

Seeds yield /plot

The highest means of seeds yield/ plot recoded for genotypes no.12 (5.60), no.1 (5.35), no.11 (5.28) and kg/plot at Al-Matana and no.13 (1.35), no. 4 (1.31) and no.1 (1.29 kg), at Al-Marashda in first season, respectively (Table 12). In the second season, the highest means recoded for genotypes no.6 (5.53) and no.9

(5.50) and no.1 (5.39) at Al-Matana and no.12 (1.33), no.1 (1.32) and no.8 (1.30kg) at Al-Marashda locations. On the other hand, the combined data (Table 12) indicate that seeds yield / plot ranged from 4.25 to 5.46 kg with an average of 4.70 for genotypes no.14 and no.12 at Al-Matana location, and from 0.93 to1.34 kg with an average of 1.15 of Al-Marashda location, respectively. Generally, the combined data revealed that the highest genotypes in seeds yield/ plot resulted from planting in Al-Matana compared Al-Marashda locations. This result came to the same conclusion mentioned before in all studied characters mentioned, except 100-seed weight. Al-Marashda location caused high reduction% which reached to 75.33 75.92 and 75.62% in the first, second years and combined means, respectively. Karadavut *et al.* (2010) found that the highest grain yield was obtained from cultivar Eresen 87 (3.21 ton/ha^{-1}) across various environments. Moreover, Abdel-Rahman *et al*. (2019) reported that the genotypes G27 and G45 gave the highest values at Sids and Nubaria locations for seed yield (ardab/Fad.) and the first one had the highest seed weight/plant.

Table 12. Means of seeds yield/plot, reduction% and stress susceptibility index (s) of the 22 faba bean genotypes

Genotypes	Seeds yield / plot, kg								
	Year 1			Year 2			Combined		
	Matana	Marashda	S	Matana	Marashda	S	Matana	Marashda	S
1	5.35	1.29	1.01	5.39	1.32	0.99	5.37	1.30	1.00
2	4.27	0.98	1.02	4.44	1.20	0.96	4.36	1.09	0.99
3	4.39	1.29	0.94	4.30	1.09	0.98	4.34	1.19	0.96
4	4.39	1.31	0.93	4.80	0.76	1.11	4.59	1.04	1.02
5	4.15	1.12	0.97	4.57	1.07	1.01	4.36	1.10	0.99
6	5.11	1.12	1.04	5.53	1.30	1.01	5.32	1.21	1.02
7	4.54	1.06	1.02	4.83	1.05	1.03	4.69	1.06	1.02
8	4.91	1.22	1.00	4.87	1.30	0.97	4.89	1.26	0.98
9	5.12	1.28	1.00	5.50	1.28	1.01	5.31	1.28	1.00
10	4.98	1.16	1.02	4.02	0.95	1.00	4.50	1.06	1.01
11	5.28	1.21	1.02	4.52	0.75	1.10	4.90	0.98	1.06
12	5.60	1.34	1.01	5.32	1.33	0.99	5.46	1.34	1.00
13	4.94	1.35	0.97	4.28	1.29	0.92	4.61	1.32	0.94
14	4.41	1.09	1.00	4.10	1.01	0.99	4.25	1.05	1.00
15	4.21	1.03	1.00	4.67	1.05	1.02	4.44	1.04	1.01
16	5.07	1.21	1.01	4.90	1.08	1.03	4.99	1.15	1.02
17	4.65	1.15	1.00	4.79	1.40	0.93	4.72	1.27	0.97
18	4.27	1.11	0.98	4.11	1.12	0.96	4.19	1.12	0.96
19	4.56	1.09	1.01	4.68	1.02	1.03	4.62	1.05	1.02
20	5.00	1.24	1.00	3.77	1.21	0.89	4.38	1.23	0.95
21	4.35	0.91	1.05	4.42	0.94	1.04	4.39	0.93	1.04
22	4.82	1.19	1.01	4.69	1.18	0.99	4.76	1.18	0.99
Means	4.74	1.17		4.66	1.12		4.70	1.15	
Red. %	75.33			75.92			75.62		
LSD 5%	0.35	0.11		0.33	0.10		0.24	0.06	
LSD 1%	0.47	0.15		0.45	0.13		0.31	0.08	

The stress susceptibility index (s) of the different genotypes respect to seeds yield/ plot revealed the same results as number of pods/plant. Eight genotypes of faba bean were susceptible to the stress of Al-Marashda location over two years and stress susceptibility index accounted more than unity (1.02-1.06). These genotypes were no. 11 (1.06), 21 (1.04), 4, 6, 7, 16 and 19 (1.02) and 15 (1.01). The other 14 genotypes were tolerant under Al-Marashda location and their stress susceptibility index estimated values less than unity (0.95-0.99). These results

agree with Abdel- Fattah (2014), who found that decreasing in crop yield will be expected by such increasing for temperature and it differs among regions. Moreover, these results are in line with those obtained by Mona *et al.* (2018).

Genetic Variability and Heritability

The genotype*environment interaction (GE) exists when the ranks of genotypes show a clearly shift from one environment to another. Such inconsistency is due to two reasons, one being the difference in response of the same set of genes to different environments and the other being the expressions of different set of genes in different environments as mentioned by Karadavut *el al* (2010). Moreover, the genotypic component being the heritable part of the total variability and its magnitude on yield and its component characters influences the selection strategies to be adopted by the breeders. The genetic parameters i.e., phenotypic (pcv) and genotypic (gcv) coefficients of variability diverse from one character to another. The values of pcv and gcv% were high for 100-seeds weight (19.09 and 18.06), number of seeds per plant (76.11 and 69.78) and seeds weight per plant (68.83 and 65.52%, respectively). While, they accounted very low estimates i.e., 0.64 and 0.58% for weight of seed per plot, respectively (Table 13). Bakhiet *et al.*(2015) found high pcv for seed weight/plant in the second season, and no. seeds/plant in the first and second season. High gcv estimates were observed for seed weight/plant in the second season and number of seeds per plant in both seasons. Moderate gcv estimated seed weight/plant in the first season. Low gcv was observed for seed yield in both seasons. Tadale *et al.* (2019) indicated that pcv and gcv for seed yield/plant ranged from 23.05 to 1.08% and 23.26% to 1.20% under different environments, respectively. The slight discrepancy between pcv and gcv caused high and unreliable estimates of each of broad sense heritability and genetic advance from selection for all studied traits. Consequently, broad sense heritability estimates that there was graduation for all studied characters and ranged from 0.65 for number of branches per plant to 0.98 for seed weight per plant.This result indicated that the effect of environment was lower than genetic effect inheritance of studied traits, hence, high estimates of expected genetic advance gave higher values more than one hundred as followed 457.22%, 418.95% and 115.93% for traits i.e. number of seeds per plant, seed weight per plants and 100 seed weight, respectively. Otherwise, the low value recorded for seed yield/ plant (3.96%). The high heritability estimates along with high genetic advance for seed yield/ plot indicating an additive gene action in its inheritance for that trait. Similar results were obtained by Sheelamary (2015) and Chaudahary *et al.* (2018) found that the genotypic coefficients of variability were high for seed yield/plant followed by number of seeds/plant, while, the values were low for number of seeds/plant. Bakheit *et al.* (2015) obtained the highest estimates of broad sense heritability for all studied traits i.e., No. of pods/plant, No. of seeds /plant, seed weight/plant and seed yield/plot respectively Gupta *et al.* (1998) reported that high heritability was followed by high genetic advance for all studies characters i.e. 100 seed weight, biological yield and grain yield. These results also are in an agreement with those reported by Sharma (1995).

Table 13. Genetic parameters for different agronomic traits in faba bean genotypes for over years and locations

Genetic parameters	Traits			
	No. of seeds/plant	Seed yield/plant	100 - Seed weight	Seed yield /plot
P.C.V	76.11	68.83	19.09	0.64
G.C.V	69.78	65.52	18.06	0.58
H^2	0.97	0.98	0.98	0.97
GA % 5	332.04	240.64	42.17	0.11
GA% of mean	457.22	418.45	115.93	3.86

Conclusions

The present study revealed that the maximum faba bean yield and its components were obtained from Al-Matana compared to Al-Marashda locations for all studied traits. The highest mean values of seeds yield /plant over two years were recorded for genotypes no.4 (113.20), no. 9 (127.33) and no.16 (107.07 g) at Al-Matana location. The stress susceptibility showed that 14 faba bean genotypes were susceptible to the stress and as considered susceptible to Al-Marashda location. But the other 8 genotypes considered tolerant to that condition. Overall means, Al-Matana gave the highest values of seed yield. Consequently, this might be useful in identifying promising faba bean genotypes for yield potential to breeding programs.

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تقييم الاختلافات الوراثية لطرز الفول البلدي تحت ظروف بيئيه مختلفة

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الملخص

أجريت هذه الدراسة لتقييم 22 تركيب وراثي في منطقتي المراشده والمطاعنه للموسمي الشتويين 2018 -2019 و2019-2020. أوضحت نتائج التحليل المفرد والمشترك للسنين التي أجريت فيها التجربة والتفاعل بين الأماكن والسنين وجود اختلافات معنوية لكل الصفات المدروسة. وعليه أظهرت قيم متوسط التحليل المشترك لمنطقه المطاعنة ارتفاعا اعلي من منطقه المراشدة في كل الصفات المدروسة. أيضا سجلت صفه عدد بذور النبات الفردي للطرز الوراثي رقم (4) 147,6 والطرز (6) 144,28 والطرز (9) 142,33 في المطاعنة والطرز رقم (8) 49,20 و (9) 48,67 والطرز رقم 12 45,00 في المراشدة. سجلت المطاعنة اعلي قيم لصفه محصول النبات الفردي بمتوسط قيم 127.33 و113.20 و107.07 جم للطرز 9 و4 و16 في المطاعنة على التوالي. من جانب أخر تراوحت قيم صفه وزن 100 بذره من 71.33 إلى 94,86 بمتوسط 79,37 جم إلى 71,01 إلى 92,08 بمتوسط 79، 64 جم تحت منطقتي المطاعنة والمراشدة على التوالي. سجلت منطقه المطاعنه أعلى قيم لصفه وزن القطعة التجريبية. سجلت نسبه النقص في صفه عدد البذور للنبات (%) اعلي قيم في منطقه المراشده عن المطاعنه حيث بلغ 58,4 و72,75 و61,19 في الموسم الأول والثاني ومتوسط الموسمين معا على التوالي.

أوضح مؤشر الحساسية لظروف الإجهاد بمنطقه المراشدة أن 22 طرز وراثي يمكن زراعتهم في منطقه المراشدة بينما 8 من هذه الطرز تعتبر أكثر تحملا لظروف المنطقة.

أظهرت 10 طرز وراثية قدره عالية لتحمل ظروف الإجهاد. يمكن اعتبار هذه الطرز الوراثية متوافقة للزراعة تحت ظروف منطقه المراشده بينما 12 طرز الأخرى هي الأكثر تحملا لهذه الظروف. لوحظ وجود فروق طفيفة بين معامل الاختلاف المظهري ومعامل الاختلاف الوراثي متلازما مع ارتفاع في الكافي الوراثي بالمعني العريض وتقدم وراثي للانتخاب لكل الصفات المدروسة. تراوحت قيم المكافئ الوراثي بالمعنى العريض بين 0,97 إلى 0,98 لكل الصفات المدروسة.