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

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ABSTRACT

The development of high yielding cultivars is a primary objective in most faba bean breeding program. This study is an attempte to evaluate sixty faba bean genotypes under different environment; Sids Research Station in Middle Egypt and Nubaria Research Station in North Egypt, during winter growing seasons 2014/2015 and 2015/2016.The experimental design was an alpha lattice with two replications. The combined analysis of variance over years were significant for most trait. The results for plant height showed that G2 and G50 had the tallest genotypes at Nubaria and Sids locations, respectively. The G42 recorded the highest values for number of pod, seeds and seed weight.plant^{-1} at Sids location, whereas, G18 genotype recoded the highest number of pods. Plant $^{-1}$ at Nubaria location. G49 and G40 recorded the heaviest 100 seed weight at Sids location, while the genotype G51 had the heaviest value at Nubaria location. Regarding seed yield (ardab.Fad^{-1}), the genotypes G27and G45 gave the highest values at Sids and Nubaria locations, respectively. The cluster analysis classified the tested genotypes in both locations to four main different groups, the first group had the highest seed yielding (ardab. fad^{-1}), plant height and seed weight. Plant $^{-1}$, followed by the third group cluster in the location Sids.

Key wards: alpha lattice, cluster analysis, genotypes, faba bean.

INTRODUCTION

Faba bean (*Vicia faba*, L.)is one of the most important food and feed legumes in the world. In Mediterranean countries and China, Faba bean provides a valuable source of cheep protein for food. In developed countries, it is mainly used as a feed. Also, Faba bean contributes to farmers income and improves soil fertility through biological nitrogen fixation.

A rich and diverse germplasm collection is the backbone of successful crop improvement program. Genetic resources have played a major role in providing source of resistance to biotic and a biotic stresses. It is important not only to collect genetic resources, but also to evaluate, document and utilize for immediate and long-term breeding programs.

The world cultivated area by faba bean was 2.55 million hectares, which yielded a total output of 4.3 million tons (FAO, 2012). In Egypt, the average of cultivated area over the last caple of years (2012–2018) was about 113.000 Faddan with an average yield of 9.2 ardab. Fad^{-1} with a total production of 119,000 ton, whereas, the consumption reached 420,000 ton. It is required to expand faba beans production to meet the high demotic demands. This expansion, forced to take-place in newly reclaimed areas (Bakry et al, 2011).

Suitable experimental design is a basic tool for validating error term of differences. Multi-environments experiments require wise choice of design and data manuplation.

The goal of this study was to evaluate newly developed promising faba bean genotypes under variable environmental conditions using alpha lattice experimental design and calculate similarity and dissimilarity parameters among genotypes using cluster analysis

MATERIALS AND METHODS

Two field experiments were carried out at two different locations; Sids Research Station in Middel Egypt and Nubaria Research Station in North Egypt, ARC, during the two growing seasons 2014/2015 and 2015/2016, to evaluate sixty faba bean genotypes . Soil analysis of experimental sites were presented in Table (1). The sixty tested genotypes (from G1 to G60) were four Egyptian commercial cultivars (Giza 429, Misr 3, Sakha 1 and Giza 834), and 56 genotypes developed by the Legume Crops Research Section, Agricultural Research Center, Egypt. The name and pedigree of faba bean genotypes were presented in Table 2.

Faba bean genotypes were laid out in a combined an alpha lattice design with two replications as described by Patterson and Williams (1976). Each replication was divided into five incomplete blocks with twelve plots for each. The layout of the field experiment was a grid of 10 rows and 12 columns in the two growing seasons and two locations as shown in Table. (3). The randomization of 60 genotypes was done with GenStat v.14 software (Payne et al., 2011).

Each plot consisted of four ridges, three m. long and 0.6 m apart (plot area = 7.2 m^2) with one seed hill-1,20 cm apart. Seeds of all genotypes were inoculated and hand planted at density of 15 plants per ridge. All other agricultural practices were maintained at optimum levels to maximize faba bean productivity. At maturity, ten guarded plants were taken at random from each experimental plot for each genotype. The following data were recorded: plant height (cm), number of branches, pods, seeds and seed weight. Plants 100-seed weight (g) and seed yield (ardab.fad^{-1}) (oneardab = 155 kg and one faddan = 4200 m^2).

Statistical analysis Methods

Combined Alpha lattice designs are partially balanced designs because some pairs of genotypes did not meet in any incomplete block (termed as 0), other pairs of genotypes came together in the incomplete blocks once (termed as 1), others came together twice (termed as 2). Accordingly, there are many available orders of alpha lattice designs but the two orders of (0, 1) and (0, 1, 2) are considered the most efficient and accurate structures. In the current work, the layout plan of the 60 tested genotypes followed the order of (0, 1). Data of seed yield was separately analysized for each year as well as combined analysis over the two years in each location (Patterson and Williams, 1976) after insurance of homogeneity of individual error term. However, the valid standard error was used to estimate the least significant difference (LSD) to compare each pair-wise genotype means.

Cluster analysis: Cluster analysis is driven by the trade of between minimizing the Euclidean distance of observation within a cluster and maximizing the Euclidean distance between clusters (Vural and Karasu, 2007). This was done by SPSS software (Ver. 16.0.1, SPSS Inc), to find groups of genotypes on the basis of coordinates of principal component analysis.

Table 1: Soil physic-chemical properties of the experimental two sites (Water Soils, and Environment Research Institute, ARC, Giza).

Soil properties	Location	
	Sids	**Nubaria**
Mechanical analysis :		
Sand %	9.5	52.41
Silt %	31.9	27.64
Clay %	60.6	19.67
Texture grand	Clay	Sandy loam
Soil analysis		
S. P. %	48.77	31.6
P^H	7.72	8.24
E.C. dSm	1.04	1.73
Organic Carbon %	0.53	0.13
Organic Matter %	0.91	0.21
$CaCo_3$%	11.61	22.63
Soluble Nitrogen(mg.kg)	62.46	14.72
Total Nitrogen %	0.028	0.014
Available _P %	7.62	3.23
Available _K %	311.60	107.9
EDTA_ extractable :		
Fe ppm	8.60	3.2
Mn ppm	4.31	0.19
Zn ppm	4.10	0.21
Cu ppm	1.81	0.17
Soluble Cations(meql^{-l}):		
Ca^{++}	3.00	4.18
Mg^{++}	1.36	1.62
Na^{+}	5.12	9.36
K^{+}	0.98	2.14
Soluble Anions (meql^{-l}):		
CO_3^{--}	0.00	0.00
HCO_3^{-}	1.51	3.95
Cl^{-}	1.72	11.7
SO_4^{--}	7.23	1.74

Table 2: The name and pedigree of the sixy faba bean genotypes.

Code	Genotypes	Pedigree	Code	Genotypes	Pedigree
G1	2097/391/2014	Nubaria 2 x Cairo 5	G31	2114/471/2014	Misr 3 x Cross 1906
G 2	2097/392/2014	Nubaria 2 x Cairo 5	G32	2114/472/2014	Misr 3 x Cross 1906
G 3	2104/395/2014	Nubaria 3 x Cairo 4	G33	2114/473/2014	Misr 3 x Cross 1906
G 4	2104/399/2014	Nubaria 3 x Cairo 4	G34	2115/475/2014	Misr 3 x Cross 1907
G 5	2104/400/2014	Nubaria 3 x Cairo 4	G35	2115/476/2014	Misr 3 x Cross 1907
G 6	2105/407/2014	Nubaria 3 x Cairo 25	G36	2115/477/2014	Misr 3 x Cross 1907
G7	2106/410/2014	Nubaria 3 x Cross 1714	G37	2115/478/2014	Misr 3 x Cross 1907
G8	2107/413/2014	Nubaria 3 x Cross 1906	G38	2115/479/2014	Misr 3 x Cross 1907
G9	2107/414/2014	Nubaria 3 x Cross 1906	G39	2115/480/2014	Misr 3 x Cross 1907
G10	2107/416/2014	Nubaria 3 x Cross 1906	G40	2115/482/2014	Misr 3 x Cross 1907
G11	2107/420/2014	Nubaria 3 x Cross 1906	G41	2115/483/2014	Misr 3 x Cross 1907
G12	2107/421/2014	Nubaria 3 x Cross 1906	G42	(Giza 3x(837/461/83)) x Cairo 25	Cross 943 x Cairo 25
G13	2107/422/2014	Nubaria 3 x Cross 1906	G43	(Giza 3x(837/461/83)) x Cairo 25	Cross 943 x Cairo 25
G14	2107/425/2014	Nubaria 3 x Cross 1906	G44	(Giza 3x(837/461/83)) x Cross 1906	Cross 943 x Cross 1906
G15	2108/433/2014	Nubaria 3 x Cross 1907	G45	(Giza 3x(837/461/83)) x Cross 1906	Cross 943 x Cross 1906
G16	2018/434/2014	Nubaria 3 x Cross 1907	G46	(Giza 3x(837/461/83)) x Cross 1906	Cross 943 x Cross 1906
G17	2110/437/2014	Misr 3 x Cairo 4	G47	(Giza 3x(837/461/83)) x Cross 1906	Cross 943 x Cross 1906
G18	2110/440/2014	Misr 3 x Cairo 4	G48	(Giza 3x(837/461/83)) x Cross 1907	Cross 943 x Cross 1907
G19	2110/441/2014	Misr 3 x Cairo 4	G49	2120/501/2014	Cross 943 x Cross 1907
G20	2110/442/2014	Misr 3 x Cairo 4	G50	2121/503/2014	Cairo 4 x Cairo 5
G21	2110/443/2014	Misr 3 x Cairo 4	G51	2121/504/2014	Cairo 4 x Cairo 5
G22	2110/444/2014	Misr 3 x Cairo 4	G52	2123/505/2014	Cairo 4 x Cross 1714
G23	2110/450/2014	Misr 3 x Cairo 4	G53	2123/512/2014	Cairo 4 x Cross 1714
G24	2112/451/2014	Misr 3 x Cairo 25	G54	2124/513/2014	Cairo 4 x Cross 1906
G25	2112/452/2014	Misr 3 x Cairo 25	G55	2124/522/2014	Cairo 4 x Cross 1906
G26	2113/454/2014	Misr 3 x Cross 1714	G56	Sids 16	(Giza40x Misr2)×(Giza 716 × T.W)
G27	2114/455/2014	Misr 3 x Cross 1906	57	Giza 429	Selection from Giza 402
G28	2114/459/2014	Misr 3 x Cross 1906	58	Misr 3	Misr 1 x Cairo 1
G29	2114/465/2014	Misr 3 x Cross 1906	59	Sakha 1	716/724/88 x 620/283/85
G30	2114/468/2014	Misr 3 x Cross 1906	60	Giza 843	461/854/83 x 561/2076/85

Table 3: Field layout of alpha lattice design with 60 genotypes in 2 complete replications. Each replicate contained 5 blocks (B) and each row contained 12 genotypes (G).

Rep.	Block No.	Row No.	G. No. 1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	12	7	11	38	8	2	32	24	50	9	46	54
	2	2	49	45	42	27	22	59	31	41	18	36	19	26
	3	3	25	29	23	51	48	53	43	15	55	4	47	37
	4	4	21	40	17	35	33	34	16	60	30	52	28	14
	5	5	57	20	39	5	56	6	3	13	58	1	10	44
2	1	1	12	22	16	30	28	23	58	56	36	29	6	2
	2	2	42	60	13	46	55	59	34	49	37	50	20	8
	3	3	1	53	47	19	38	40	31	57	11	33	48	14
	4	4	24	10	4	52	18	43	21	5	39	32	26	54
	5	5	44	7	3	41	27	17	15	9	35	25	51	45

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance at Sids and Nubaria Locations for faba bean yield and yield components (combined data of two years) were given in Tables (4 and 5). Results revealed that, the mean squares of genotypes were highly significant ($p \leq 0.01$) for all studied traits in both locations, exceptfor, number of branches.plant $^{-1}$ in Sids and number of pods. Plant $^{-1}$ in Nubaria. These results a considerable genetic variation in those materials, indicate might results were these in agreement with those obtained by Zarea-Fizabady and Ghodsi (2004), Abd El-Mohsen and Abo-Hegazy (2013), Abd El-Shafi (2014) and Mona et al. (2018).

Mean performance of genotypes at Sids and Nubaria locations for faba bean, yield and yield components were presented in Tables (6 and 7). The results indicated that, the highest values of plant height were obtained from genotype G50 followed by G5 and G53with averages of 145.0, 142.5 and 141.5 cm in Sids location, respectively. While in Nubaria location, the highest values were obtained from genotypes G2 followed by G1 and G39 with averages of 123, 115.8 and 112.6 cm., respectively. Regarding to the number of branches. plant $^{-1}$, in Sids location the values were ranged from 3.48 to 5.73(G6 or G13). While at Nubaria location, the values ranged from 2.67 (G2) to 6.21 (G14). On the other hand, the genotype G42 and G11 gave the highest value for number of pods.plant^{-1} as 37.52 and 18.55 in Sids and Nubaria location, respectively. Data for number of seed.plant^{-1} showed that, genotypes G42, G43 and G22 recorded 120.77, 102.17 and 101.95 respectively, in Sids location, whereas, in Nubaria location genotypes G46, G44 and G50 scored 62.28, 60.88 and 58.54, respectively. In addition, G13 had the highest value of 100- seed weight followed by G40 and G47 with average of 101.8 and 99.86 (g), respectively in Sids location, while in Nubaria location, genotypes G51 followed by G10 and G8 recoded of 88.93, 85.98 and 84.3 g, respectively (Table 6 and 7). These results are in agreement with those obtained bySilim and Saxena, (1992) and Al Ghamdi, (2007).

The highest value of seed weight.plant^{-1} was recorded by the genotype G42 (98.55 g), followed by genotype G1 (89.1 g) and G22 (88.8g), while the lowest values were exhibited by cultivar Miser3 (19.75 g), Giza 429 (26.55 g) and genotype G32 (33.9 g) in Sids location. Whereas at Nubaria location the seed weight.plant^{-1} ranged between 50.0 g for genotype G44 to 21.47 g for genotype G15.

Regarding faba bean seed yield, the highest value was produced by genotype G27 (15.57 ardab.fad^{-1}) followed by genotype G53 (15.1 ardab.fad^{-1}) and genotype G52 (14.58 ardab.fad^{-1}), while the least seed yield was produced by genotype G23 (9.68 ardab.fad^{-1}) in Sids region. On the other hand, in Nubaria location, the highest value of seed yield given by genotype G45 followed by genotype G55 and G44 (11.63, 10.74 and 10.5kg, respectively), while the least seed yield was produced by genotype G15 (4.58 ardab.fad^{-1}) followed by genotypes G29 (4.74 ardab.fad^{-1}) and G21 (4.95kg).These results are in accordance with those obtained by (1991, Al-Rifaee, 1999 ,and Rehab, 2014).

Table 4: Mean squares of 60 faba bean genotypes (yield and yield components combined over two years) at Sids location.

S.O.V	df	Plant height cm	No. of branches. plant^{-1}	No. of pod .plant^{-1}	No. of seed.Plant-1	seed weight. Plant^{-1}(g)	100-seed weight(g)	Seed Yield ard.fad^{-1}
Year	1	966.5**	3.15	6274.00**	1966**	40.44	5117.36	0.3
Year*rep	2	338.1	10.05**	391.38**	138.7**	63.46	334.51	23.46
Year*rep*blok	20	252.4**	1.17	71.83	252.7**	236.16**	79.52	3.66**
Genotypes	59	333.4**	1.27	142.66**	362.2**	485.92**	175.84**	5.85**
Year*G	59	223.6**	1.51	91.31**	223.6**	364.51**	99.13	3.17**
Residual	98	129.7	1.17	48.83	129.1	95.73	59.45	4.53

*,** = Significant at 1 and 5% probability level, respectively.

Table 5; Mean squares of 60 faba bean genotypes (yield and yield components) (combined over two years) at Nubaria location.

S.O.V	df	Plant height cm	No. of branches. plant^{-1}	No. of pod .plant^{-1}	No. of seed.Plant-1	seed weight. Plant^{-1}(g)	100-seed weight(g)	Seed Yield ard.fad^{-1}
Year	1	606.74	60.669**	362.3	9154.36**	3.63	34881.8	2.058
Year/ rep	2	111.65	41.945**	1.9	729.15**	26.57	1422.5	14.754
rep*block/ Year	20	84.65**	3.01*	8.17	123.97	34.43**	546.7	1.62
Genotypes	59	112.18**	3.47*	17.95	212.61**	136.93**	871.1**	8.53**
Year*G	59	112.56**	1.91	20.5	132.34	35.168**	428.7	1.42
Residual	98	61.46	2.62*	15.69	99.6	8.92	48.8	6.25

*,** = Significant at 1 and 5% probability level, respectively.

Table 6: Means of plant height, number of branches, pods and seeds. plant $^{-1}$ for sixty faba bean genotypes at Sids location.

Genotypes	Plant height cm	No. of branches. Plant^{-1}	No. of pods. Plant^{-1}	No. of seed. plant^{-1}	Genotypes	Plant height cm	No. of branches. Plant $^{-1}$	No. of pods.Plant^{-1}	No. of seed. Plant $^{-1}$
G1	127.50	4.08	22.48	64.45	G31	124.50	5.63	17.72	54.27
G2	130.00	4.53	21.72	65.23	G32	132.50	4.85	11.52	35.72
G3	128.70	4.90	21.72	55.9	G33	132.50	4.60	18.27	55.3
G4	117.50	5.48	24.4	74.28	G34	134.50	4.43	21.47	66.15
G5	117.50	4.83	20.47	65.4	G35	133.70	4.98	21.72	70.98
G6	126.20	5.73	29.52	84.35	G36	127.50	4.83	20.07	58.02
G7	117.50	5.23	30.77	98.82	G37	132.50	4.95	30.85	88.52
G8	107.50	4.98	20.60	68.58	G38	116.20	4.73	34.45	91.2
G9	110.00	5.65	23.90	71.2	G39	135.00	5.70	22.4	67.1
G10	110.00	5.08	15.95	52.85	G40	140.00	4.83	26.52	81.6
G11	120.00	5.65	16.02	54.77	G41	127.50	5.35	32.10	97.65
G12	102.50	4.23	19.27	59.98	G42	125.00	4.53	37.52	120.77
G13	125.00	5.73	25.65	69.85	G43	139.50	5.70	28.9	102.17
G14	135.00	4.18	29.65	86.70	G44	103.70	4.28	12.6	50.58
G15	111.20	4.65	27.4	64.43	G45	137.50	4.30	30.17	86.12
G16	122.50	4.55	26.4	75.62	G46	132.50	5.63	28.00	88.97
G17	125.00	4.90	25.2	84.72	G47	131.20	5.53	28.15	83.22
G18	115.00	4.45	18.47	68.47	G48	135.00	5.38	22.8	73.53
G19	132.50	4.35	23.77	78.65	G49	130.00	4.53	32.07	95.2
G20	132.50	4.40	22.27	60.53	G50	145.00	4.25	22.77	77.9
G21	126.20	3.83	19.97	59.08	G51	142.50	4.15	24.47	68.9
G22	125.00	4.65	31.4	101.95	G52	138.70	4.03	24.07	71.75
G23	122.50	3.98	17.02	58.15	G53	141.50	4.33	28.02	83.82
G24	128.70	3.48	18.65	64.45	G54	130.00	4.78	31.7	91.07
G25	125.00	5.45	20.47	60.00	G55	130.00	4.78	19.35	56.03
G26	117.50	4.28	17.9	60.17	G 56	125.2	4.44	26.43	77.95
G27	127.50	4.15	14.05	50.35	Giza 843	120.6	5.14	21.01	77.92
G28	130.00	3.78	14.97	49.95	Giza 429	122.5	4.75	11.5	33.5
G29	118.70	4.65	16.5	54.33	Misr 3	100	4.5	11.5	29.75
G30	135.00	4.03	20.15	53.27	Sakha 1	127.3	4.98	21.74	64.48

L.S.D 0.05 Plant height: 8.04, No. of pods.Plant^{-1} : 4.89 and No. of seed.plant^{-1}:13.77

Table 7: Means of seed weight. Plant $^{-1}$, 100-seed weight and seed yield for sixty faba bean genotypes at Sids location.

Genotypes	Seed weight. Plant^{-1} (g)	100-seed weight (g)	seed yield ard.fad^{-1}	Genotypes	Seed weight. Plant^{-1} (g)	100-seed weight (g)	seed yield ard.fad^{-1}
G1	50.05	73.40	13.59	G31	43.03	79.23	13.69
G2	46.60	68.65	11.37	G32	33.90	94.55	13.10
G3	41.82	74.65	8.92	G33	43.35	78.69	12.72
G4	54.40	73.50	11.34	G34	60.72	92.06	13.47
G5	40.15	60.63	12.24	G35	66.15	92.45	13.73
G6	62.70	75.54	11.29	G36	62.12	97.82	12.35
G7	78.08	78.28	11.96	G37	71.27	80.16	12.77
G8	60.78	91.46	11.34	G38	83.35	91.73	11.48
G9	60.97	84.98	12.97	G39	54.80	83.75	12.35
G10	47.65	90.37	11.24	G40	89.10	101.18	13.22
G11	44.97	86.02	12.52	G41	70.55	73.2	13.38
G12	49.45	81.89	10.97	G42	98.55	94.8	12.10
G13	71.08	101.6	11.38	G43	76.90	74.75	12.92
G14	73.65	84.33	11.17	G44	37.52	72.71	13.22
G15	47.17	78.86	11.32	G45	67.70	84.22	12.31

Cont. Table 7: Means of seed weight. Plant $^{-1}$, 100-seed weight and seed yield for sixty faba bean genotypes at Sids location.

Genotypes	Seed weight. Plant^{-1} (g)	100-seed weight (g)	seed yield ard.fad^{-1}	Genotypes	Seed weight. Plant^{-1} (g)	100-seed weight (g)	seed yield ard.fad^{-1}
G16	69.82	90.10	10.20	G46	67.77	79.49	12.32
G17	70.27	81.49	13.16	G47	83.45	99.86	11.97
G18	58.40	85.79	11.12	G48	48.30	65.56	11.75
G19	62.90	78.64	13.06	G49	84.90	86.56	12.13
G20	54.90	89.87	12.89	G50	63.32	80.76	11.66
G21	47.03	78.00	12.04	G51	56.87	82.10	11.48
G22	88.80	87.13	13.02	G52	53.97	74.83	14.58
G23	52.60	87.33	9.68	G53	61.80	73.58	15.10
G24	54.15	92.85	13.60	G54	73.37	80.42	12.79
G25	52.22	88.48	11.88	G55	43.15	75.32	10.96
G26	49.60	83.67	12.10	G 56	66.79	83.68	11.06
G27	44.80	89.38	15.57	Giza 843	64.23	83.03	12.19
G28	41.83	83.73	12.42	Giza 429	26.25	78.34	12.78
G29	49.45	93.57	12.30	Misr 3	19.75	66.19	10.62
G30	47.55	88.68	13.05	Sakha 1	58.14	89.1	12.56

L.S.D 0.05 Seed weight.Plant^{-1}: 11.15, 100-seed weight: 6.37 and seed yield: 1.50

Table 8: Means of Plant height, number of branches, pods and seeds.plant^{-1} for sixty faba bean genotypes at Nubaria location

Genotypes	Plant height cm	No. of branches. Plant^{-1}	No. of pods. Plant^{-1}	No. of seed. plant^{-1}	Genotypes	Plant height cm	No. of branches. Plant^{-1}	No. of pods. Plant^{-1}	No. of seed. plant^{-1}
G1	115.80	4.75	12.66	44.34	G31	102.10	5.17	15.16	102.10
G2	123.00	2.67	11.19	45.69	G32	106.40	5.75	14.23	44.62
G3	105.70	3.25	13.79	45.36	G33	104.00	4.38	14.52	43.42
G4	110.90	3.08	14.46	45.23	G34	102.80	4.50	13.78	41.89
G5	100.90	3.96	12.23	38.33	G35	100.40	4.13	13.47	47.33
G6	111.50	4.63	14.64	49.65	G36	98.40	4.79	16.50	39.69
G7	103.10	4.67	14.89	53.29	G37	102.10	5.58	13.72	45.44
G8	105.00	5.25	13.32	33.78	G38	100.00	4.13	13.57	41.06
G9	104.90	5.42	11.23	34.90	G39	112.60	4.00	13.58	44.91
G10	102.10	4.33	16.75	46.83	G40	101.60	3.88	12.24	44.03
G11	102.70	3.67	18.55	42.88	G41	98.60	5.71	13.37	46.72
G12	101.60	2.75	14.95	42.04	G42	109.80	5.08	14.79	50.98
G13	99.70	5.63	12.54	37.48	G43	101.00	5.29	12.72	52.38
G14	97.90	6.21	12.95	32.20	G44	107.10	4.33	17.74	60.88
G15	96.50	4.96	9.77	26.69	G45	107.40	5.50	14.93	53.23
G16	97.40	4.63	12.48	36.41	G46	115.30	4.92	15.72	62.28
G17	106.20	3.79	13.65	40.83	G47	104.40	4.25	14.58	40.74
G18	110.30	4.71	18.36	50.53	G48	109.70	3.58	15.77	58.18
G19	110.90	5.42	15.97	46.34	G49	104.80	4.13	12.92	40.19
G20	110.40	5.38	11.58	40.48	G50	108.20	2.83	17.42	58.54
G21	108.30	4.21	10.82	41.61	G51	95.30	3.00	13.48	42.93
G22	106.20	4.79	14.56	40.28	G52	105.40	3.21	15.28	44.00
G23	107.00	4.42	16.34	48.89	G53	103.70	3.13	13.85	43.77
G24	92.70	5.33	12.89	42.26	G54	110.10	2.92	12.48	44.33
G25	105.40	5.38	10.70	37.45	G55	110.80	3.00	10.88	36.28
G26	106.70	3.08	11.66	32.29	G 56	99.2	3.83	12.15	38.79
G27	104.70	4.50	13.64	38.04	Giza 843	101	3.25	12.98	39.48
G28	107.80	4.25	10.24	28.14	Giza 429	101.6	2.92	9.82	35.87
G29	93.00	4.54	14.57	50.13	Misr 3	105	2.96	15.66	50.85
G30	104.00	5.38	11.41	34.00	Sakha 1	105	4.63	15.26	50.28

L.S.D 0.05 Plant height: 5.54,No. of branches.Plant^{-1} : 1.14and No. of seed.plant^{-1}:7.06

Table 9: Means of seed weight. Plant^{-1}, 100-seed weight and seed yield for sixty faba bean genotypes at Nubaria location

Genotypes	Seed weight. Plant^{-1} (g)	100-seed weight (g)	seed yield ard.fad^{-1}	Genotypes	Seed weight. Plant^{-1} (g)	100-seed weight (g)	seed yield ard.fad^{-1}
G1	40.95	83.57	8.44	G31	28.98	74.09	6.55
G2	36.87	80.52	7.46	G32	32.74	72.79	6.42
G3	34.08	74.98	7.50	G33	32.25	76.99	6.88
G4	31.19	70.92	6.78	G34	26.05	62.77	7.64
G5	27.76	73.92	5.86	G35	34.28	72.3	6.51
G6	38.92	78.77	7.19	G36	30.68	77.17	6.13
G7	44.20	83.15	6.30	G37	33.95	74.72	7.17
G8	27.95	84.31	7.48	G38	28.51	71.09	6.17
G9	27.57	79.29	6.47	G39	32.32	71.74	6.69
G10	40.52	85.98	7.05	G40	36.29	82.54	5.88
G11	34.53	80.30	8.34	G41	38.69	82.86	9.01
G12	34.86	82.05	6.62	G42	41.34	81.32	7.57
G13	30.59	82.89	6.45	G43	43.53	83.23	7.70
G14	26.54	73.35	7.63	G44	50.00	82.01	10.57
G15	21.47	78.48	4.58	G45	43.44	82.70	11.63
G16	26.61	73.03	6.58	G46	47.86	76.67	7.53
G17	32.95	79.63	7.04	G47	34.06	81.10	6.36
G18	36.57	72.44	7.03	G48	45.07	77.05	9.36
G19	33.37	72.22	6.43	G49	31.33	77.89	8.93
G20	30.40	75.26	5.53	G50	48.42	82.36	10.41
G21	28.25	69.38	4.95	G51	38.14	88.93	6.03
G22	28.45	71.63	6.14	G52	36.52	82.90	7.83
G23	36.71	74.34	7.96	G53	38.19	87.37	7.67
G24	31.83	74.84	5.91	G54	28.27	65.76	6.75
G25	26.88	72.68	6.12	G55	28.17	77.36	10.74
G26	25.44	77.60	8.07	G 56	29.02	75.03	5.62
G27	27.90	74.61	6.36	Giza 843	29.47	73.13	5.91
G28	18.42	65.87	5.86	Giza 429	24.96	69.64	8.44
G29	37.96	77.01	4.74	Misr 3	32.64	67.34	6.78
G30	28.57	79.59	7.24	Sakha 1	39.42	77.56	8.00

L.S.D 0.05 Seed weight.Plant-1: 5.45 , 100-seed weight: 2.05and seed yield: 1.77

Cluster analysis:

Cluster analysis creates groups of samples based on their distances. It seeks objects groups of the same properties which differ at the same time from the next objects group**.**

The genetic euclidean distances among 60 genotypes derived from the two locations (Sids and Nubaria) were aggregated into phenotypic groups. The cluster analysis was used as an efficient procedure to emerge the structural relationships among tested genotypes and provides a hierarchical classification of them.

In the present work, the similarity levels of the two locations were estimated based on seed yield plant^{-1} and its related characters. Such genotypes were separated into meaningful genetic division based on knowledge of pedigree and type of these genotypes (Table 10). A dendrogram was constructed on the basis of co-ordinates of principal component analysis. Cluster group rankings were obtained based on Ward's minimum variance. Phylogenetic tree, in figures (1 and 2). The clustering pattern of genotypes derived from sids showed four kinds of grouping. These four clusters consisted of 15, 15, 10 and 20 members, respectively (Fig. 1) Clusters I, II, III and IV have the similarity level 7.18, 10.42, 4.12 and 9.38, respectively. The cluster (I) aggregated the genotypes that had the highest plant height^{-1} and seed yield.

While the third (III) cluster had the No. of branches and seed weight plants^{-1} but the fourth had the highest No. of pods, seeds plant^{-1} and 100-seed weight. So that, the first cluster (I) aggregated the genotypes that had the highest seed yield ardab.fad^{-1} followed by third cluster (III). The dendogram of population derived from the Nubaria consisted of four clusters. The genotypes were classified in each cluster presented 16, 12, 15 and 17% of total genotypes respectively (Fig. 2). The first cluster (I) was for the highest plant height, No. of pods plant^{-1}, 100-seed weight and seed yield (ardab.fad^{-1}). By contrast, the second cluster (II) aggregated the genotypes that had the highest seed weight plant^{-1}. Also the fourth cluster aggregated the plant that had the highest No. of branches plants^{-1}. and seed yield plant^{-1}. So that, the first cluster possessed the highest estimates of most studied traits compared with the other clusters followed by the second cluster (II) (Table 11). The third cluster content most commercial cultivars. Cluster analysis provided with a complete view of the variation present among the 60 faba bean. Genotypes and it might be used by plant breeders during genetic improvement of faba bean.

Table 10: Elite genotypes of the studied traits according to the alpha lattice design in the two locations.

Traits	Sids	Nubaria
Plant height	G1, G2, G3, G14, G19, G20, G24, G27, G28, G30, G32, G33, G34, G35, G36, G37, G39, G40, G41, G43, G45, G46,G47,G48, G49, G50, G51, G52, G53,G54, G55, G57, G58, G60, G56.	G1, G2, G3, G4, G6, G8, G17, G18 G19, G20, G21, G22, G23, G25, G26 G28, G32, G42, G44, G45, G46, G48 G50, G52, G54, G55, G59, G60.
No. of branches.Plant-^{1}	G4, G5, G16, G7, G8,G9, G10, G11, G13, G17, G25, G31, G32, G35, G36, G37, G39, G40, G43, G45, G46, G47, G48, G54, G55, G57, G60.	G1, G6, G7, G8, G9, G13, G14, G15, G16, G18, G19, G 20, G22, G23, G24, G25, ,G27, G29, G30, G31,G32, G34, G36, G37, G41, G42, G43,G45,G46, G60, G56.
No. of pods.Plant^{-1}	G6, G7,G8,G9, G13, G14,G16,G17, G19, G20, G37, G38,G39, G40, G41, G42, G43, G45, G46, G47, G49, G51, G52, G53, G54, G57, G60, G56.	G4, G6, G7, G10,G11,G12, G18, G19, G22, G23, G29,G31, G32, G33, G42, G44, G45, G46, G47, G48, G50, G59, G60.
No. of seed.Plant^{-1}	G6, G7, G14,G22,G37, G38,G40, G41, G42, G43, G45, G46, G47, G49, G50, G53, G54,G57, G60, G56.	G1, G2, G3, G4, G6, G7, G10, G18 G19,G20, G29, G32, G35, G39, G40 G41, G42, G43, G44, G45, G46, G48 G50, G52, G59, G60.
seed weight.Plant^{-1}(g)	G6, G7,G8,G9, G13, G14, G17, G19, G22,G34, G35, G36,G37, G38, G40, G41, G42, G43, G45, G46, G47, G49, G50, G53, G54, G57, G60, G56.	G1, G2, G3, G6, G7,G8, G10, G11,G12, G17,G18, G23, G29, G35, G37, G40, G41,G42, G43,*G44*, G45, G46, G47,G48 G50, G51, G52, G53, G59, G60.
100-seed weight(g)	G8,G11, G13, G14,G16,G17, G18, G20, G22, G23,G24, G25, G26, G27, G28, G29,G30, G32, G34, G35, G36, G38, G39, G40, G45, G47, G49, G57, G60, G56.	G1, G2, G6, G7,G8, G9, G10,G11,G12, G13, G15,G17,G26, G40, G41, G42, G43 ,G44, G45, G47, G49, G50, G51, G52, G53, G55, G57,G 60,G59.
Seed Yield Ard.fad^{-1}	G1,G9,G11, G17, G19, G20, G22, ,G24, G27, G28, G30, G31,G32, G33, G34, G35, G36, G37, G39, G40, G41, G43, G44, G46, G52, G53, G57, G58, G60.	G1, G2, G3, G6, G11,G14,G23,G26, G30, G37, G41, G42, G43, G44, G45, G46, G48 G50, G52, G53, G55,G58, G60.

Table 11: Summary of cluster analysis showed the included genotypes, distance level and cluster mean of the 60 faba bean genotypes using the studied yield characters.

Location	No. of genotypes /Cluster	Distance level	Plant height cm	No. of branches. plant^{-1}	No. of pod. plant^{-1}	No. of seed. plant^{-1}	seed weight. Plant^{-1}(g)	100-seed weight(g)	Seed yield ardab. fad^{-1}
Sids	15	7.18	131.72	4.27	19.53	59.86	84.94	49.96	13.45
	15	10.42	116.57	4.69	19.41	60.22	77.11	46.49	11.21
	10	4.12	123.36	5.26	20.50	64.68	85.75	56.02	12.60
	20	9.38	130.29	4.89	29.37	88.43	85.49	74.90	12.01
Nubaria	16	9.88	109.34	4.59	15.19	52.57	79.46	42.06	8.29
	12	4.86	103.08	3.81	14.51	42.11	82.50	34.79	7.18
	15	7.02	103.71	3.57	13.03	41.08	71.60	29.35	7.07
	17	8.04	102.39	5.13	12.74	38.45	74.92	28.89	6.13

Table 12: Distributing pattern of 60 genotypes of faba bean into four clusters based on D2 statistics

No. of Cluster	NO.G		Genotypes included	
	Sids	Nub	Sids	Nubaria
1	15	16	G1,G19,G52,G53,G20,G34,G30,G35, G24,G27,G21,G28,G33,G32,G57.	G1, G2, G6, G42, G23, G59, G18, G19, G41, G43, G46, G44, G48, G50,G7, G45.
II	15	12	G2,G55,G3,G4,G48,G5,G8,G10,G12, G15, G18, G26, G23, G44, G58.	G8,G52,G17,G49,G33,G47,G40,G10, G11,G12, G51, G53.
III	10	15	G9,G17,G56,G11,G31,G25,G59,G39, G29, G36.	G3,G4,G35,G58,G34,G39,G54,G5,G60,G16, G38, G56, G26, G55, G57.
Iv	20	17	G6,G46,G41,G43,G37,G54,G7,G38, G22,G49,G42,G13,G47,G40,G14,G4 5,G50,G51, G16, G60.	G9,G30,G13,G14,G15,G20,G25,G21,G28, G22, G27, G31, G36, G32, G37, G24, G29.

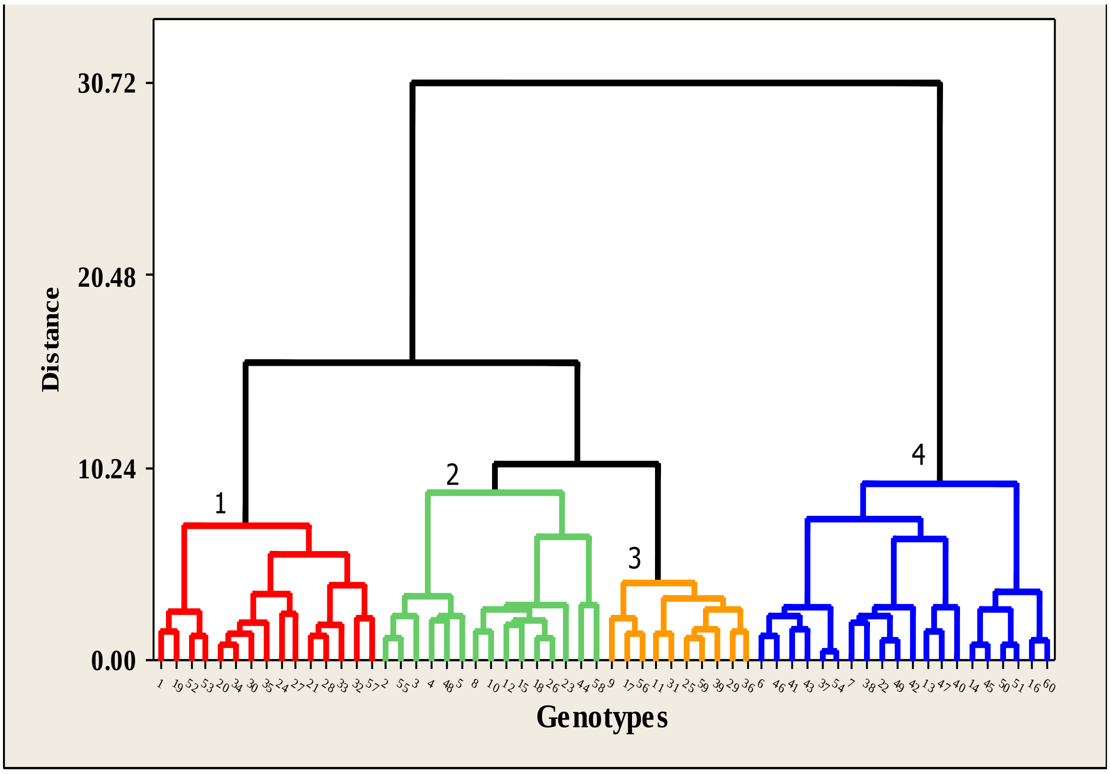

Fig. 1: Dendrogram of 60 faba bean genotypes in sids basd on seven characters

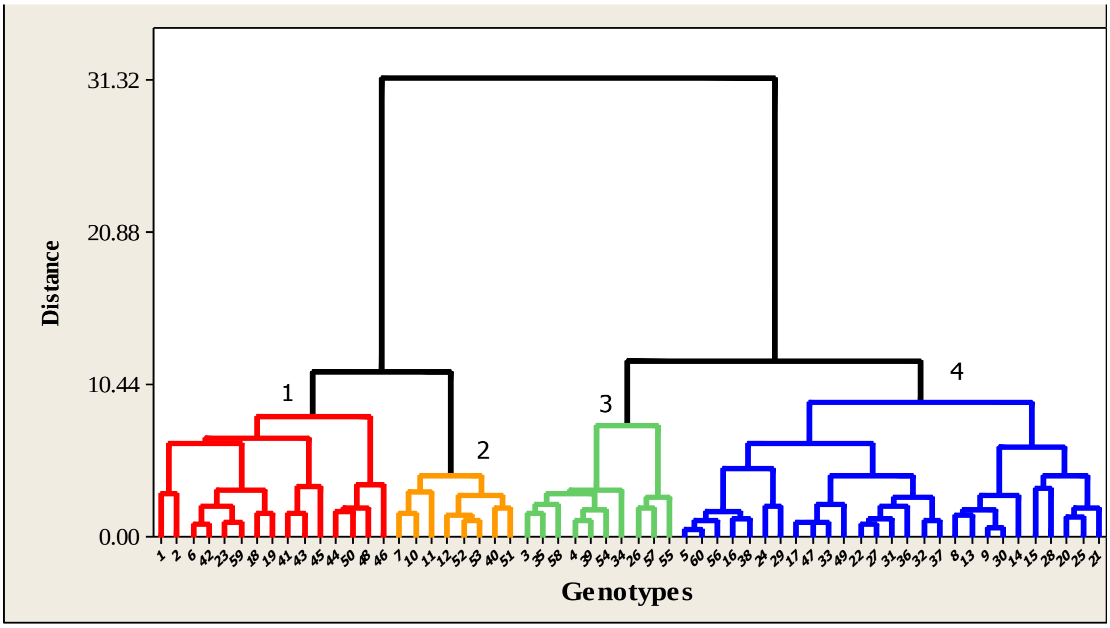

Fig. 2: Dendrogram of 60 faba bean genotypes in Nubaria based on seven characters

CONCLUSIONS

The studied faba bean genotypes showed variability in most of the studied traits. Overall, the genotypes 27, 52 and 53 at Sids and 45, 50 and 55 at Nubaria gave the highest values of seed yield (ardab. fad^{-1}). So this might be useful in identifying promising genotypes of yield potential to breeding programs.

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الملخص العربي

تقييم التباين بين تراكيب الوراثية من الفول البلدي في بيئات مختلفة

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يعتبر تطوير انتاج اصناف عالية المحصول الهدف الاساسي فى معظم برامج التربيه لمحصول الفول البلـــدي، وتهدف هذه الدراسة الى تقييم ستون تركيب وراثي من الفول البلدى لمحصول البذور ومكوناته تحت ظروف بيئية مختلفة بكل من محطة البحوث الزراعية بسدس (منطقة مصر الوسطي) ومحطة بحوث النوبارية منطقة شمال الوجه البحري في الموسمين الزراعيين ٢٠١٤ /٢٠١٥ و٢٠١٥/٢٠١٦. كان التصميم الاحصائي المستخدم هو التحليـــل التجميعى ألفا الشبكي بمكررتين لكل موقع . اظهرت النتائج من جدول تحليل التباين الفروق المعنويه لمعظم الصفات المدروسة. اظهرت النتائج أن أطوال التراكيب الوراثيه كانت G2 وG50 لكل من منطقتي النوباريه وســـدس علـــى الترتيب، كما اوضحت النتائج التي تم الحصول عليها أن التركيب الوراثي G42 قد أعطى أعلى القيم بالنسبة لعـــدد القرون وعدد البذور والمحصول للنبات في موقع سدس، في حين أن التركيب الوراثي G18 كان اعلي في صفة عدد القرون للنبات فيموقع النوبارية وقد وسجل التركيب الوراثي G40 في منطقة سدس والتركيب الوراثيG51 في موقع النوبارية اعلي قيمة لصفة وزن ١٠٠ بذرة. وفيما يتعلق بمحصول البذور للفدان فقد أعطت التراكيب الوراثية G27 وG45 أعلى القيم بكل من سدس والنوبارية على التوالي. تم استخدام تحليل ألفا الشـــبكى للتأكيـــد علـــي ارتبـــاط مجموعات من التراكيب الوراثية معا فى الصفات تحت الدراسة بشكل مباشر أو غير مباشر. كما أتضح من نتـــائج التحليل العنقودي فى كلا الموقعين أن التراكيب الوراثية المختبرة أمكن تقسيمها إلي أربعة مجموعات متباينـــة فيمـــا بينهما حيث أظهرت النتائج أن المجموعة الأولى فى سدس احتوت علي أعلي التركيب الوراثيه بالنسبة لصفة طـــول النبات ومحصول النبات(جرام) ووزن البذور(أردب/فدان) تلتها المجموعة الثالثة بينما أعطي موقع النوبارية أعلـــي التركيب الوراثيه في معظم الصفات تحت الدراسة. ويمكن الاستفادة من هذه الدراسة في أنتخاب أفضـــل التراكيـــب الوراثية ملائمه للظروف البيئيه واعتماده كصنف محسن عالى الانتاجية لتلك المنطقـــة، إضـــافة لاســـتخدام بقيـــة الآصناف كأصول وراثية اعتمادا على الصفات التى تتفوق بها على الاصناف المحلية لادخالها فى برامج التربيـــة مستقبلا.