J. Plant Production, Mansoura Univ., Vol. 8(6):665 -669, 2017

Genotype x Environment Interaction Effects on Heritability and Genetic Advance for Yield and its Componentes of Some Faba Bean Genotypes.

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ABSTRACT

This investigation was carried out at Sakha Agriculture Research Station. Kafer El-Sheikh, Egypt during during 2013/14 and 2014/15 seasons to evaluate thirteen faba bean promising lines under early (mid- October) and late (mid- November) sowing dates comparing with three commercial cultivars. Each sowing date was conducted in a separate replicated complete blocks experiment and combined analysis was done over both sowing dates and growing seasons to study the effect of genotype x environment interaction on heritability and genetic advance for seed yield and some related traits. Highly significant mean squares of seasons were detected for all studied traits. Sowing dates and genotypes mean squares were highly significant for all traits tested. Mean squares of sowing date x season interactions were highly significant for chocolate spot reaction, No. of seeds/plant and seed yield /plant. Highly significant mean squares of the interactions between genotypes and seasons were found for chocolate spot, No. of pods and seeds/plant, 100-seed weight and seed yield /plant. The interactions between genotypes and sowing dates were highly significant for maturity date, no. of seeds/plant and seed yield/plant. The highest values of predicted genetic advance were mainly due to high vales of heritability and the latest was coupled with high phenotypic coefficient of variability.

Keywords: Sowing date, heritability in broad-sense, expected genetic advance, predicted genetic advance.

INTRODUCTION

Faba Bean (*Vicia fab*a L.) is one of the major winter legume crops grown in the Mediterranean region, and has considerable importance as a low cost food rich in proteins and carbohydrates in Egypt. Faba bean is the most important legume crop in Egypt, due to its high nutritive value for human food and its role as a break crop in cereal rotation system. The cultivated area was about 112.000 feddan in the least five seasons with an average yield of 9.0 ardab/faddan. The total production in 2015/16 season was about 119.000 tons, while the total consumption was estimated to be about 420.000 tons. This means that the percentage of self-sufficiency is only about 28%. So, to reduce the gab between production and consumption, the most effective is being developing new cultivars with high yielding potentiality and using the proper cultural practices.

In North parts of Egypt, the planted area represent about 85% of the total cultivated faba bean area, where the dominant summer crop is rice. After rice research program has released the short duration cultivars, some farmers intended to plant faba bean crop in September and October, while the optimum sowing date for the commercial cultivars is the first half of November. Under this early sowing, the seed yield decreased significantly due to the high level of infection with foliage diseases i.e. chocolate spot (*Botrytis fabae*) rust (*Uromysis fabae*), high infestation with insects and abnormal climatic. Since this time a new breeding activity started at Sakha in order to develop new faba bean cultivars, resistant or tolerant to foliar diseases and suitable for early sowing conditions. Some promising lines were recently selected from this program according to their high yielding potential and resistance to foliar diseases along with their good performance under early sowing.

Sowing date as it affects the timing and duration of the vegetative and reproductive stages, it also contribute largely to seed yield. On the other hand, the damage caused by foliar diseases and Aphids in North parts of Egypt could be decreased if the proper genotype was selected and sown on the proper date. Amer *et al*., 1992, Hussein *et al*., 1994, El-Galaly *et al*., (2006) found that, sowing on mid -October gave the highest seed yield. Mahmoud (1996), found that, late sowing dates reduced the amount of diseases infection, while the highest seed yield was obtained from optimum sowing date. However, sowing date was one of the main agronomic practices that could directly effect on the level of insect infestation (Dent,1991) as it created asynchrony between phonology of both crop and the insect pest (Ferro,1987).

The objectives of this investigation were to evaluate some selected promising lines under early and late sowing dates, and to study the effect of genotype x environment interaction on heritability and genetic advance for seed yield and some related traits.

MATERIALS AND METHODS

This investigation was conducted Sakha Agricultural Research Station farm, Kafr El-Sheikh Governorate Egypt during the seasons of 2013/14 and 2014/15. Thirteen faba bean promising lines selected from the breeding program at Sakha, for their high yield potential and/ or resistance to foliar diseases were evaluated under two sowing dates comparing with three commercial cultivars. The Names, pedigrees and remarkable characters of the studied genotypes are presented in Table 1.

Sowing dates were mid- October (early) and mid-November (late) in both seasons. Each sowing date was conducted in a separate randomized complete blocks design (RCBD) experiment with three replications as outlined by Snedecor and Cochran (1982) and then combined analysis across sowing dates was calculated. Bartlett test has been done for error mean squares of the environments to estimate homogeneity or not, while combined analysis was done in the case of homogeneity. Each plot consisted of four ridges, 3 m long and 60 cm apart. The recommended package of cultural practices was followed.

Table 1. Names, pedigrees and remarkable characters of studied faba bean genotypes.

Genotype	Pedigree	Remarkable characters @
Line1	(Sakha 2 x Misr 1) x (Giza 40 x Giza 429)	LM and R
Line2	(Giza 3 x Giza 429) x (Giza 40 x Giza 429)	EM and S
Line3	(Giza 3 x Giza 429) x (Giza 40 x Giza 429)	EM and R
Line4	(Giza 3 x Misr 1) x (Giza 716 x Giza T.W)	EM and S
Line5	(Sakha 1 x Misr 1) x (Giza 716 x Giza T.W)	EM and S
Line6	(Giza 40 x Giza 716)	EM and R
Line7	(Nubaria 1 x Giza 716)	EM and R
Line8	Sakha 1 x Otona	EM and R
Line9	Sakha 1 x Sakha 2	EM and R
Line10	Giza 717 x Otona	LM and S
Line11	Giza 717 x Otona	EM and R
Line12	Giza 717 x Sakha 2	LM and R
Line 13	Misr 1 x ILB5329	EM and R
Giza 40	Selected from Rebai 40	EM and HS
Sakha 1	Giza 716 x 620/283/85	EM and R
Sakha 3	Individual selection from Giza 716	LM and HR

EM= Early mature LM=Late mature
HR=High resistance to foliar diseases R= Resistance to foliar diseases
HS=High susceptibility to foliar diseases S= Susceptibile to foliar diseases

In both seasons, measurements were taken on the basis of individual plants as follows: chocolate spot disease reaction, rust disease reaction, number of days to maturity, No. of branches / plant, No. of pods/plant, No. of seeds / plant, 100-seed weight, and seed yield / plant.

Reaction to foliar diseases was recorded on mid February and mid March for chocolate spot and rust diseases, respectively; according to the disease scales suggested by Bernier *et al*. (1984) as presented in Table (2).

Table 2. Rating scale for chocolate spot and rust diseases according to Bernier *et al.* (1984)

Rate	Chocolate spot scale
1	No disease symptom (highly resistant)
3	Few small discretes lesions (Resistant)
5	Some coalesced lesions with some defoliation (moderately resistant)
7	Large coalesced lesions, 50% defoliations, some dead plants (susceptible)
9	Extensive lesions on leaves, stems and pods, severe defoliation, heavy sporulation, death of more than 80% of plants (highly susceptible)
	Rust scale
1	No pustules or very small non-sporulating flecks (high resistant)
3	Few scattered pustules covering less than 1% of the leaf area, and few or no pustules on stem (resistant)
5	Pustules common on leaves covering 1-4% of leaf area, little defoliation and some pustules on stem (moderately resistant)
7	Pustules very common on leaves covering 4-8% of leaf area, some defoliation and many pustules on stem (susceptible)
9	Extensive pustules on leaves, petioles and stem covering 8—10% of leaf area, many dead leaves and several defoliation (highly susceptible).

Table 3. Mean squares (MS) and expected mean squares (EMS)

S.O.V	d.f	MS	EMS
Replication	r-1		
Genotype x Season (G x S)	(g-1)(s-1)	MSgs	$\sigma^2 e + r\sigma^2 g + rs\sigma^2 g s$
Genotype (G)	(g-1)	MSg	$\sigma^2 e + r\sigma^2 g$
Error	(r/sd) x (g-1)	MSe	$\sigma^2 e$

The phenotypic $\sigma^2 ph$ and genotypic variances $\sigma^2 g$ were calculated from the partitioning of mean squares (MS) as follows:

$$\sigma^2 g = MSg - Mse / r$$
$$\sigma^2 g\, s = MSgs - MSg / rs$$
$$\sigma^2 e = MSe ,$$

Where r is the number of replications , s is the number of seasons

$\sigma^2 g$ is the genotypic variance

$\sigma^2 g\, s$ is the genotypic x seasons interaction variance

$\sigma^2 e$ is the environmental variance

$$\sigma^2 p = \sigma^2 g + \sigma^2 g\, s / r + \sigma^2 e / r\, s ,$$

where $\sigma^2 p$ is the phenotypic variance

The genotypic (GCV) and phenotypic (PCV) coefficients of variation were estimated according to the procedures outlined by Johanson, *et al*. (1955) thus: PCV = σ ph /$\bar{x}$) X 100 , GCV= (σ g/ $\bar{x}$) X 100, where σ ph is the phenotypic standard deviation, σ g genotypic standard deviation and $\bar{x}$ is the grand mean of the character . The expected genetic advance under selection, assuming 5% selection intensity was calculated as suggested by Allard (1960): Ga = k X σ ph X H, where: Ga = Expected genetic advance , k = Selection differential (2.06 at 5% selection intensity) σ ph= phenotypic standard deviation and H is the broad –

sense heritability. Genetic advance a percent of mean (Ga %) which known as predicted genetic advance was calculated using the formula : Ga% = (Ga/ x̄) X 100.

RESULTS AND DISCUSSION

The analysis of variance

The analysis of variance for all studied traits are shown in Table 4 . The combined analysis indicated the presence of significant differences between the two seasons for all studied traits, except for the reaction of rust disease where the difference was not significant. Therefore, it was clear that these traits could behave in different way from season to another, while for rust disease the behavior was similar in both seasons. Sowing date's mean squares were highly significant for all studied traits, indicating that the behavior of these traits has changed from sowing date to another. Mean square of sowing date x season interaction were highly significant for chocolate spot, No. of seeds/plant and seed yield/plant, indicating that the effects of sowing dates on these traits could be changed from season to another. While, for the rest traits where the interaction was not significant it might indicate that, sowing date could be stable from season to another. It was be observed that, highly significant genotypes mean squares were recoded for all studied traits, which indicate that, great variations are exist among the studied genotypes. These results are in good agreement with those reported by Amer, *et al* (1992), El- Deeb, *et al* (2006) and Abebe , *et al* (2015)

Concerning, genotype x season interaction, highly significant mean squares, were detected for chocolate spot disease, No. of pods/ plant, No. of seeds/plant , 100-seed weight and seed yield / plant , indicating that studied genotypes were affected by seasons and their performance differed from season to another for these traits in view . Highly significant mean squares of genotype x sowing date interactions were found for maturity date, No. of seeds / plant and seed yield / plant, indicating that genotypes were more influenced by the changing of sowing date for these traits. The triple interaction of genotypes x seasons x sowing dates mean squares was highly significant for No. of pods/ plant, No. of seeds/ plant and seed yield /plant, which might indicate that the performance of genotypes was differed with respect to these traits form season to season and from sowing date to another. However, the insignificant interaction for the other traits might indicate that the performance of genotypes would be stable over both sowing dates environments. The obtained results are in good agreement with those reported by Gurmu, *et al*. (2009) and Amin (2010), who found significant genotype x environment interaction mean squares for soybean seed yield. Ngalamu *et al*.(2013) found significant sowing date, year, genotype mean squares and significant interaction between genotype and year, genotype and sowing date and the second order interaction of genotype x year x sowing date mean squares for some soybean traits which agreed with the obtained results. Also, Hussein, *et al*. (2006), Khalil *et al*.(2011) and Abebe, *et al*. (2015) reported that, significant genotype , environment and genotype x environment interaction and the environment explained higher sum of squares for the response variable seed yield of faba bean.

Table 4. Mean square of Studied characters of 16 faba bean genotypes grown under two sowing dates (D) during 2013/14 and 2014/15 seasons .

SOV	df	Studied Traits							
		Chocolate spot reaction	Rust Reaction	Maturity Date	No. of branchs/ plant	No. of Pods/ plant	No.of seeds/ Plant	100-Seed weight	Seed yield/ plant
Season (S)	1	388.17**	3.00	37.63*	150.88**	752.48**	3430.7**	5087.58**	630.75**
Sowing date(D)	1	27.76**	24.08**	21526.51**	1.84*	172.71**	2028.0**	969.39**	2517.20**
SD	1	34.17**	0.19	9.63	0.88	32.92	1073.5**	45.59	838.34**
Rep/(SD)	8	3.29**	2.60**	17.49	0.58	6.70	62.28	58.73	47.90
Genotype(G)	15	5.77**	3.43**	62.28**	1.40**	41.36**	338.95**	548.35**	192.59**
GS	15	2.49**	1.27	7.66	0.52	26.04**	192.09**	104.38*	134.48**
GD	15	0.94	0.73	35.01**	0.32	13.45	104.40**	69.99	102.94**
GSD	15	0.85	0.85	5.91	0.55	29.53**	176.18**	50.88	131.15**
Error	120	0.94	0.79	8.75	0.42	8.68	42.51	49.34	28.71

***and** significant at0.05 and 0.01 levels of probability, respectively.**

Genetic variation :

Phenotypic (PCV) and genotypic (GCV) coefficients of variation magnitudes (Table 5) were higher for rust disease reaction, No. of seeds/plant , No. of pods/plant, seed yield/plant at both early and late sowing dates and chocolate spot disease reaction at late sowing date. While the same values were relatively low for maturity date and 100-seed weight at both environments. In addition, the coefficients of variation showed that the relative variation in No. of pods/plant was comparable to that of No. of seeds/plant and seed yield/plant, however, the latest values were nearly twice that of 100-seed weight and about eight times that of maturity date. It could be observed that, the values of phenotypic and genotypic coefficient of variability were closed together for 100-seed weight and maturity date at both sowing dates environments, indicating that these traits were less affected by environmental factors. These results are in the same line with those obtained by Nassib, *et al*. (1984), El-Refaey (1987), Gurmu, *et al*. (2009). and El-Metwally (2013).

Heritability and genetic advance:

The heritability in brood- sense was estimated for all studied traits (Table 5). The highest heritability values were found for no. of seeds/plant, 100-seed weight and seed yield/plant at late sowing date, where more than 85% of the phenotypic variance were attributed to the genetic effects. Also, high heritability estimates were recoded for No. of pods/plant at late sowing date along with , No. of seeds/plant , 100-seed weight, chocolate spot disease reaction and seed yield/plant at early sowing date where more than 74% of the phenotypic variances were due to genetic ones. Such high heritability estimates were also supported by the very low discrepancy between phenotypic and genotypic coefficients of variability indicating that, these traits were highly inherited. However, moderate heritability values were detected for no. of branches/plant at both environments, no. of pods/plant at early sowing date and rust disease reaction at both environments, where their values ranged from 56% to 68%. Low heritability value (22.5%) was observed for maturity date at early sowing date.

Table 5. Phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability(H) in broad-sense, expected(G.a)and predicted genetic advance (Ga%) at early (ES)and late sowing(LS) dates.

Trait	SD	$\bar{X}$	PCV%	GCV%	Variance components			H	G.a	G.a%
					V. p	Vg	V.e			
Chocolate spot	ES	5.062	14.07	12.13	0.51	0.38	0.13	74.34	1.09	21.54
	LS	4.302	18.21	15.83	0.61	0.46	0.15	75.54	1.22	28.34
Rust	ES	3.573	18.15	14.37	0.42	0.26	0.16	62.70	0.84	23.45
	LS	2.702	18.22	13.64	0.27	0.15	0.12	56.10	0.60	21.05
Maturity date	ES	187.11	0.88	0.42	2.71	0.61	2.10	22.51	0.76	0.41
	LS	165.94	2.21	1.98	13.50	10.75	2.75	79.63	6.03	3.63
No. of branches/plant	ES	2.702	15.71	11.91	0.18	0.10	0.08	57.41	0.50	18.58
	LS	2.506	13.01	10.79	0.11	0.07	0.03	68.75	0.46	18.43
No. of pods/plant	ES	13.51	16.90	13.23	5.21	3.20	2.01	61.36	2.88	21.35
	LS	11.62	17.05	15.21	3.92	3.12	0.80	79.61	3.25	27.95
No. of seeds/plant	ES	39.34	16.44	14.47	41.85	32.42	9.43	77.48	10.32	26.24
	LS	32.84	17.24	15.95	32.04	27.42	4.62	85.59	9.98	30.39
100-seed weight	ES	90.53	7.30	6.49	43.64	34.57	9.07	79.22	10.78	11.91
	LS	86.03	8.96	8.33	59.45	51.41	8.04	86.48	13.74	15.97
Seed yield/ plant	ES	35.07	15.34	13.31	28.96	21.80	7.16	75.28	8.35	23.80
	LS	27.83	16.19	15.18	20.30	17.85	2.45	87.93	8.16	29.32

Predicted genetic advance (G.a%), expressed as the percentage of expected genetic advance (G.a) to the trait mean, varied from 0.41% for maturity date at early sowing date to 30.39% for No. of seeds/plant under late sowing date. However, it could be observed from the obtained results listed in Table 5 that, the highest values of predicted genetic gain upon selection were found for No. of pods/plant (27.95%) , No. of seeds/plant (30.39%), chocolate spot disease reaction (28.34%) and seed yield/plant (29.32%) at late sowing date. In soybean, Johnson *et al*. (1955) reported that, heritability estimates along with genetic advance upon truncation selection where the top 5% of the progeny in selected are usually useful in predicting the resultant effect of selection than heritability values alone. From this point of view, the highest values of predicted genetic advance referred before were mainly due to high values of heritability and the latest was coupled with high phenotypic coefficient of variability. While moderate values of predicted genetic advance were related to moderate values of heritability and phenotypic coefficient of variability. In this respect, moderate values of heritability i. e., 57.41% for No. of branches/plant at early sowing date, 62.7% and 56.1% for rust disease reaction at early and late sowing date, respectively were coupled with moderate values of phenotypic coefficient of variability 15.71%, 18.15% and 18.22%, respectively. Low values of predicted genetic advance i.e., 0.41% and 3.63% for maturity date at early and late sowing dates, respectively were correlated with low values of heritability and phenotypic coefficient of variability (0.88% and 2.21%)at early and late sowing dates, respectively.

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تأثيرات تفاعل التركيب الوراثى وُالبيئة علي المكافىء الوراثى والتقدم الوراثى لمحصول البذور ومكوناته لبعض التراكيب الوراثيه فى الفول البلدى

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تم تنفيذ هذا البحث في محطة البحوث الزراعية بسخا – كفر الشيخ – مصر خلال موسمى الزراعة2013 /14 و 15/2014 لتقييم ثلاثة عشر سلالة مبشرة من الفول البلدي تحت ميعادين للزراعة(مبكر في منتصف اكتوبر ومتأخر في منتصف نوفمبر) وذلك بالمقارنه بثلاثة أصناف تجاريه ، وقد تم تنفيذ كل ميعاد زراعه في تجربة قطاعات كاملة العشوائيه منفصله ذات الثلاثة مكررات وتم اجراء التحليل الأحصائى التجميعى لكل من ميعادي الزراعه والموسمين لدراسة تأثير التفاعل بين التركيب الوراثى والبيئه على المكافىء الوراثى بمعناه الواسع والتقدم الوراثى لمحصول البذور و بعض الصفات المرتبطة به . كان تباين المواسم عالى المعنويه لجميع الصفات تحت الدراسه وكان تباين مواعيد الزراعة والتراكيب الوراثية عالى المعنويه لجميع الصفات . كان تباين التفاعل بين مواعيد الزراعه والمواسم عالى المعنويه لصفات التبقع البنى ، عدد البذور بالنبات ومحصول البذوربالنبات. كان تباين التفاعل بين التراكيب الوراثيه و المواسم عالى المعنويه لصفات التبقع البنى ، عدد القرون بالنبات ، عدد البذور بالنبات ، وزن100بذره ومحصول البذرة بالنبات. كان تباين التفاعل بين التراكيب الوراثيه ومواعيد الزراعه عالى المعنويه لصفات النضج ،عدد البذوربالنبات ومحصول البذور للنبات . كانت أعلى القيم للتقدم الوراثى المتنبأ به ترجع أساسا الى قيم المكافىء الوراثى العاليه، والمكافىء الوراثى كان مرتبطا مع القيم العالية لمعامل الاختلاف المظهرى .