Egypt. J. Plant Breed. 20(5):851 – 867 (2016)

VARIATION IN THE TOLERANCE OF SOME FABA BEAN CULTIVARS TO *Orobanche crenata* UNDER NATURALLY INFESTED SOILS.

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ABSTRACT

This study was carried out in Gemmiza Agricultural Research Station, Agricultural Research Center during two successive seasons 2014/2015 and 2015/2016 in order to determine genotypic and phenotypic coefficient variation, heritability and genetic advance for yield and its contributing parameters in three faba bean genotypes (Giza 3, Misr 1 and Giza 843) planted in six different natural infested soil with Orobanche crenata collected from six different farms at Agricultural Research Stations (Shandweel, Mallawy, Sids Giza, Nubaria and Sakha) comparing with soil of farm of Gemmieza Res. Station (free) as a check in lysometers. The area of Lysometer 1 x 2 m = 2 m^2 and 1.5 m height. Determination of the separated seeds of Orobanche was performed visually by microscope. Analysis of variance for studied traits showed significant ($P \leq 0.01$) differences among the cultivars, soils and interaction between them. The estimated value of heritability in broad sense was found for days to 50% flowering (67.4%), no. of branches/plant (82.1%) , no. of pods/plant (88.1%), no. of seeds/plant (93.0%), seed yield/plant g. (92.7%), date of Orobanche emergence (%97.9), no. of Orobanche spikes/m^2 (76.8%) and Orobanche dry weight g/m^2 (77.3%). High heritability indicated that selection based on mean would be successful in improving these traits. Expected genetic gains from selecting the top 5% of the characters under study as a percent of the mean revealed 37.4, 57.9, 57.1 and 60.9% for no. of branches / plant, no. of pods/plant, no. of seeds/plant and seed yield/plant g. High heritability estimates along with high genetic advance for seed yield/plant indicated an additive gene action in its inheritance.

Key words: ***Faba bean, Orobanche, Soils, Heritability, Selection gain.***

INTRODUTION

Faba bean (*Vicia faba* L.) is a cool season legume crop used as a source of protein in human diets , as fodder and a forage crop for animals , and for availability of nitrogen in the biosphere (Duc *et al* 2010 and Rubiales 2010). However, faba bean acreage has declined due to low and unstable yields as well as incidence of diseases (Stoddard *et al* 2010). The major constraint for faba bean cultivation in the Mediterranean area and west Asia is broomrape infection (Perez – de-Luque *et al* 2010 and Maalouf *et al* 2011). Broomrapes are root parasitic weeds which are completely dependent on the host due to the lack of chlorophyll and functional roots. In Egypt one species of *Orobanche* causes serious damage to crops, *Orobanche crenata* Forsk.

Several measures are available for broomrape management, including cultural practices and chemical control; however they are not always fully effective or applicable in low input crops such as faba bean (Rubiales *et al* 2009 and Perez-de Luque *et al* 2010). Resistance against broomrape in faba bean is difficult to access, scarce, of complex nature and of low heritability. Still number of cultivars with various levels of resistance to *Orobanche cerenata* have been released by different faba bean breeding programs (Nassib *et al* 1982, Cubero and Hemandez, 1991, Khalil and Erskin, 1999, Kharrat *et al* 2010 and Maalouf *et al* 2011), all of them using Egyptian line F402as the major donor of resistance. In Egypt three cultivars tolerant to *Orobanche crenat*a, Giza 843, Misr 1 and Misr 3 were developed by Food Legume Section A.R.C. and another three at the Agron. Dept. Faculty of Agriculture Cairo University.

The cultivated area devoted to faba bean in Egypt was 322 thousand faddan in 1997/98-2001/02 seasons but declined to only 98 thousand faddan in 2011/2012 season and increased to 123 thousand faddan in 2013/2014 season (The annual Economic Reports. Agricultural Economic Sector, Ministry of Agriculture, Egypt). However, the seed yield per unit area has increased from 8.13 to 9.4 ardab/ faddan in the last season, with an increase of 15%. Despite the increasing in productivity, the total production is not reaching the self-sufficiency. These percentages reduced to 35% in 2013/014 season.

The objectives of this research were to evaluate some varieties of faba bean under different soils naturally infested with *Orobanche crenata* and estimate the variability, heritability and genetic advance for yield and its components.

MATERIALS AND METHODS

Experimental procedures

This study was carried out in Lysometers at Gemmiza Agricultural Research Station, Agricultural Research Center, Egypt during two successive seasons 2014/2015 and 2015/2016. Three genotypes of faba bean varied in pedigree and characters were used in this study. The genotypes were sown in the Lysometers during both seasons at 15 November. The origin and pedigree of these genotypes are presented in Table (1). The six different soils naturally infested with *O. crenata* collected from six different farms at Agricultural Research Stations (Nubaria, Giza, Sakha, Shandweel, Mallawy and Sids) in addition to soil of farm of Gemmieza Res. Station (free) as a check. The area of Lysometer 1 x 2 m = 2 m^2 and 1.5 m height. All the lysometers were filled by a sandy soil at 1.25 m height and the top area was filled by the collections of different soils naturally infested with *O. crenata* at 0.25 m. high. The type of different soils and seed bank of *Orobanche* in both seasons were presented in (Table 2). Before sowing a random sample of soils (1.0 kg soil) at three depths (0 – 5cm, 5 – 15cm and 15 – 25cm) was taken from each plot to count seeds of *Orobanche* in both seasons. Seed extraction was done by sieving of the samples through copper sieves that were 5 mm in diameter.

Table 1. The pedigree and *Orobanche* reaction of the genotypes used in the study.

No.	Genotypes	Pedigree	*Orobanche* reaction
1	Giza 3 improved	Individual plant selection from Giza 3	Susceptible
2	Misr 1	(G3 X 123A /45/76) X (62/1570/66 X G2) X Romi X Habashi	Tolerant
3	Giza 843	(561/2076/85 Skh X 461/485/83)	Tolerant

Table 2. Soil characteristics of different locations naturally infested with *O. crenata* and number of *Orobanche* seeds/Kg soil in seasons 2014/2015 and 2015/2016.

No.	Location	Soil texture	*Orobanche* seed/kg soil	
			First season	second season
1	Gemmiza	Clay loam	Zero	Zero
2	Nubaria	Calcareous	20	80
3	Giza	Clay loam	140	220
4	Sakha	Clay loam	40	100
5	Shandweel	Clay loam	130	200
6	Mallawy	Clay loam	160	280
7	Sids	Clay loam	40	100

This was followed by their rinsing by water and sieving of the samples through sieves of 0.5 mm in diameter. Seeds were then dried at the room temperature and separated manually. Determination of the separated *Orobanche* seeds was performed visually by microscope (Dvorak and Krejcir 1974). The treatments were arranged in both seasons in split plot design in three replications; the main plots were randomly devoted to the three genotypes and the sub plots were randomly devoted to the seven different soils. The experimental plot consisted of three ridges 33.3 cm apart and 2m long (1 x 2 m = 2 m^2). Date of *Orobanche* emergence, number of *Orobanche* spikes/m^2 and *orobanche* dry weight g/m^2 at beginning of maturity were recorded. Yield and its components were determined for all the plants of each ridge (15 plants/ridge). The recommended cultural practices for faba bean production were adopted. Days to 50% flowering , days to 90% maturity , plant height (cm) , height to first pod (cm) , number of branches/plant , number of pods , seeds/plant, weight of seeds/plant (g) and 100 seed weight (g) were estimated on plot basis.

Estimation of genetic parameters

The mean values of the recorded data were subjected to analysis of variance according to Gomez and Gomez (1984). The mean squares were used to estimate genotypic and phenotypic variance according to Sharma

(1998). Phenotypic and genotypic variance, heritability in broad sense (h^2) were estimated using the following formula:

Phenotypic variance (δ^2 **ph) =** δ^2 **g +** $\frac{\delta^2 \text{gs}}{\text{r}} + \frac{\delta^2 \text{e}}{\text{rB}}$

where g = number of genotypes , s= number of soils and gs = Interaction

δ^2 **gs =** $\frac{(\text{MsAB - Mse})}{\text{r}}$ ‘ δ^2 **e =MSe**

Genotypic variance (δ^2 **g) =** $\frac{(\text{MSs - MSgxs})}{\text{rs}}$

Both genotypic and phenotypic coefficient of variability were computed as per the method suggested by Burton and De Vane (1953)

Genotypic coefficient of variability: GCV = $\frac{\delta g}{x^-}$ **x 100**

Phenotypic coefficient of variability: PCV = $\frac{\delta ph}{x^-}$ **x 100**

where: δ g = genotypic standard deviation

δ ph = phenotypic standard deviation

x^- = General mean of the character

The estimates of PCV and GCV were categorized by Sivasubramanian and Menon (1973):

< 15% low, 15 – 30% medium and > 30% high

Heritability in broad sense (h^2) was calculated according to Falconer and Mackay (1996)

$$(h^2) = \frac{\delta^2 g}{\delta^2 ph} \text{ x100}$$

The range of heritability was categorized according to Robinson *et al* (1949) as below:

0 – 30 low, 31 – 60 medium and > 60 high.

Genetic advance was worked out based on the formula suggested by Allard (1960) as follows:

$$GA = K \frac{\delta^2 g}{\delta^2 ph} \sqrt{\delta ph}$$

K selected material at 5% selection intensity = 2.06 and δ ph = phenotypic standard deviation.

$$GA\% = \frac{GA}{\bar{x}} \times 100$$

The range of genetic advance was categorized according to Johnson *et al.* (1955) as follows:

0 – 10% low, 10 – 20 % medium and > 20 % high.

RRESULTS AND DISCUSSION

Analysis of variance of first season (Table 3) revealed highly significant ($p \leq 0.01$) to significant ($p \leq 0.05$) differences among genotypes for all characters under study except height of first pod in both season and number of pods/plant in first season. In the first and second season the analysis of variance revealed highly significant differences among soils for all characters except 50% flowering in second season. All the characters revealed highly significant mean squares for interaction between genotypes and soils, except 50% flowering in both season. This suggested adequate amount of genetic variability among genotypes, soils and interaction between genotypes and soils may be helpful for yield improvement by selection under soil naturally infested with *O. crenata*, these results are in agreement with Darwish *et al* (1999).Mean performance of genotypes, soil and interaction is presented in Table (4).Data revealed that days to 50% flowering ranged from 48.4 to 52.7 in the first season and 43.2 to 47.5 for genotypes in the second season, respectively. No. of days to 90% maturity recorded 142.9 days for Misr 1 and decreased to125.8 for Giza 3 , due to death of plants (susceptible) at soil of Mallawy. So No. of days to maturity for Giza 3 at soil of Mallawy and interaction between cultivars and soil decreased to 93.3 and 0.0 in the first season, respectively. In the second season, No. of days to maturity decreased to 125.3, 98.2 and 0.0 day in cultivar Giza 3 for soils and interaction between cultivars and soils, respectively. The highest plant height was recorded 89.9, 99.1 and 105.2 cm. for genotypes , soils and interaction between genotypes and soils in the first season, respectively, while it recorded 72.9, 76.3 and 82.2 cm for genotypes, soils and interaction between genotypes and soils in the second season, respectively. The minimum plant height recorded 60.4 and 49.5 cm for first and second season, respectively due to death plants of Giza 3 at Mallawy soil because the highest seed number of *Orobanche* recorded in this soil. Height of first pod was recorded 21.6, 14.3 and 22.6, 17.1 cm for genotypes and soils in both seasons, respectively. The highest mean value for No. of branches per plant recorded 2.7, 3.6 and 4.1 for genotypes, soils and interaction between them in the first season, respectively, while it recorded 2.7, 2.9 and 3.4 for genotypes, soils and interaction between them in the second season, respectively.

Table 3. Mean squares of three genotypes and different soils infected with Orobanche and interaction between them for two seasons 2014/2015 and 2015/2016.

SOV	df	50% Flowering		90% Maturity		Plant height		First pod height		No. of branches/ plant	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Reps.	2	0.3	0.1	1.0	17.2	38.1	64.5	18.7	23.1	0.0	0.5
Cultivars (A)	2	105.9**	91.5**	2139.6**	2880.6**	590.5**	1111.1*	17.6	120.5	1.1*	3.1*
Error	4	0.8	2.9	0.8	3.2	25.3	91.4	6.4	31.3	0.1	0.4
Soils (B)	6	3.5*	3.9	3456.4**	2906.8**	1522.0**	870.4**	234.9**	178.8**	5.9**	1.7**
A x B	12	1.3	2.2	2920.2**	3145.9**	1394.9**	842.1**	207.5**	139.3**	0.6**	1.1**
Error	36	1.2	2.0	0.9	1.6	24.4	31.7	6.2	25.4	0.1	0.3

SOV	df	No. of pods/plant		No. of seeds/plant		Seed yield/plant		100-Seed weight	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Reps.	2	3.5	1.8	2.6	10.5	2.5	8.2	22.54	0.13
Cultivars (A)	2	11.6	68.9**	38.6**	268.7**	84.9*	149.3**	1591.36**	1037.45**
Error	4	6.5	2.7	1.2	8.1	4.9	4.2	73.52	18.29
Soils (B)	6	263.7**	11.5**	1365.0**	132.1**	902.4**	98.1**	1010.45**	969.36**
A x B	12	15.0**	22.9**	44.2**	67.2**	31.6**	38.7**	852.62**	880.72**
Error	36	1.2	1.2	2.9	3.5	3.6	2.6	33.03	14.32

SOV	df	Date of *Orobanche* emergence		No of *Orobanche* spikes/m2		*Orobanche* dry weight/m2	
		1st	2nd	1st	2nd	1st	2nd
Reps.	2	13.0	7.6	13.1	27.2	9.80	35.87
Cultivars (A)	2	1998.9**	197.4**	13750.9**	11690.2**	15279.00**	26934.97**
Error	4	7.6	3.4	7.4	30.5	6.48	72.39
Soils (B)	6	12663.1**	10779.1**	17456.8**	9240.4**	34726.95**	14716.27**
A x B	12	2636.6**	100.4**	2007.5**	1442.1**	3896.39**	3039.52**
Error	36	5.2	3.2	13.9	43.5	24.14	74.31

*** and ** : significant at 0.05 and 0.01 level of probability, respectively.**

Table 4. Mean performance of three genotypes and different soils infected with Orobanche and interaction between them for two seasons 2014/2015 and 2015/2016.

SOV		50% Flowering		90% Maturity		Plant height		First pod height		No. of branches /plant	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivars (A)	1-Giza 3	52.8	47.4	125.8	125.3	79.4	58.4	22.9	22.6	2.3	1.9
	2-Misr 1	48.4	45.8	142.9	145.7	89.9	72.9	23.3	27.4	2.7	2.3
	3-Giza 843	49.6	43.2	143.5	145.6	85.5	65.7	21.6	24.5	2.7	2.7
L.S.D 0.05		0.8	1.5	0.8	1.2	4.3	Ns	Ns	Ns	Ns	Ns
Soils (B)	1-Gemmiza	51.3	45.8	146.6	147.2	83.2	68.0	22.0	24.8	3.6	2.7
	2-Nubaria	50.6	46.4	145.0	146.8	93.8	75.8	30.0	27.9	2.8	2.2
	3-Giza	49.3	44.9	141.8	144.1	77.0	66.1	19.8	24.7	2.0	2.0
	4-Sakha	50.0	44.7	141.1	143.7	91.9	76.3	24.4	28.1	3.1	2.1
	5-Shandweel	49.9	44.9	146.2	146.8	99.1	67.9	21.0	29.9	2.3	2.9
	6-Mallawy	50.3	45.7	93.3	98.2	60.4	49.5	14.3	17.1	1.1	1.6
	7-Sids	50.3	45.9	147.9	145.2	89.3	56.0	26.9	21.2	2.6	2.4
L.S.D 0.05		Ns	Ns	0.9	2.1	4.7	5.4	2.4	4.8	0.3	0.6
1-Giza 3	1-Gemmiza	54.0	47.3	148.3	148.3	79.5	72.1	24.0	28.0	3.4	2.1
	2-Nubaria	53.7	47.7	147.0	149.7	99.0	71.5	35.0	29.8	2.7	1.6
	3-Giza	52.0	47.0	144.0	145.7	80.0	65.6	24.0	28.4	1.9	1.9
	4-Sakha	52.0	45.7	143.0	144.0	101.2	81.6	36.3	27.0	3.3	2.4
	5-Shandweel	51.7	47.3	148.3	145.7	105.2	60.7	21.6	23.9	2.2	2.8
	6-Mallawy	53.0	47.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7-Sids	53.0	49.0	149.7	144.0	91.0	57.3	19.1	21.5	2.3	2.3
2-Misr 1	1-Gemmiza	49.0	46.7	146.3	146.3	85.0	68.1	21.0	27.8	3.4	2.8
	2-Nubaria	48.0	46.0	144.0	145.0	93.0	81.4	27.0	30.4	2.7	2.2
	3-Giza	47.0	45.0	140.0	144.0	71.0	68.1	16.8	20.3	2.1	2.1
	4-Sakha	48.0	46.0	140.0	144.0	88.8	77.7	18.4	27.9	3.2	1.8
	5-Shandweel	49.0	45.0	144.0	145.7	101.0	76.9	22.0	34.9	2.4	2.3
	6-Mallawy	49.0	45.7	140.0	147.7	97.5	82.2	19.0	27.5	1.6	2.6
	7-Sids	49.0	46.0	146.3	147.0	93.0	56.3	39.0	22.9	3.1	2.3
3-Giza 843	1-Gemmiza	51.0	43.3	145.0	147.0	84.5	63.9	21.0	18.5	4.1	3.3
	2-Nubaria	50.0	45.7	144.0	145.7	89.5	74.5	27.5	23.8	3.1	2.9
	3-Giza	49.0	42.7	141.3	142.7	80.0	64.7	18.5	25.4	2.0	1.9
	4-Sakha	50.0	42.3	140.3	143.0	85.8	69.7	18.3	29.3	2.7	2.0
	5-Shandweel	49.0	42.3	146.3	149.0	91.1	66.3	19.4	31.1	2.4	3.4
	6-Mallawy	49.0	43.7	140.0	147.0	83.8	66.4	23.1	23.9	1.8	2.3
	7-Sids	49.0	42.7	147.7	144.7	84.0	54.5	22.5	19.3	2.5	2.7
L.S.D 0.05		Ns	Ns	1.5	1.5	8.2	9.3	4.1	8.4	0.5	0.9
C.V.		2.1	3.1	0.7	0.9	5.8	8.6	10.9	20.3	12.1	25.6

Table 4. Cont.

SOV		No. of pods/plant		No. of seeds/plant		Seed yield/plant (g.)		100-Seed weight (g.)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivars (A)	1-Giza 3	11.6	5.3	26.2	10.0	18.8	8.2	61.07	67.11
	2-Misr 1	12.2	8.9	28.9	16.3	22.8	13.2	77.20	81.00
	3-Giza 843	10.7	7.8	27.7	16.2	21.2	12.3	75.80	75.89
LSD 0.05		NS	0.9	0.9	1.7	NS	1.2	7.35	3.66
Soils (B)	1-Gemmiza	19.9	6.9	47.3	12.8	36.5	9.9	77.36	77.74
	2-Nubaria	12.9	8.8	30.1	18.7	21.6	15.7	71.58	82.02
	3-Giza	6.9	7.8	19.2	15.4	13.5	12.2	69.23	78.40
	4-Sakha	15.5	8.7	35.2	19.0	29.3	15.1	82.87	78.97
	5-Shandweel	9.5	6.7	24.3	13.6	17.9	10.4	74.30	76.58
	6-Mallawy	3.6	6.5	8.2	9.1	6.0	7.1	49.57	51.46
	7-Sids	12.0	5.9	29.0	10.4	21.9	8.1	75.51	77,50
LSD 0.05		1.0	0.8	1.6	1.3	1.8	1.1	5.51	3.63
1-Giza 3	1-Gemmiza	21.3	6.4	46.9	11.6	35.0	9.7	74.77	80.94
	2-Nubaria	12.4	6.5	27.5	10.7	19.0	10.6	69.20	83.34
	3-Giza	9.0	4.9	21.0	7.1	15.2	5.3	72.30	75.19
	4-Sakha	17.5	9.3	39.6	21.0	28.0	16.9	70.60	79.61
	5-Shandweel	9.7	6.3	23.4	12.2	17.2	8.7	73.60	71.61
	6-Mallawy	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00
	7-Sids	11.3	4.0	25.2	7.5	17.5	5.9	69.80	79.05
2-Misr 1	1-Gemmiza	18.3	5.2	46.6	10.3	38.4	8.5	82.27	82.49
	2-Nubaria	12.1	8.4	29.9	17.9	19.0	15.1	63.43	84.83
	3-Giza	7.8	10.8	20.2	20.4	15.8	16.9	77.83	83.43
	4-Sakha	15.4	9.2	34.6	20.7	33.0	16.0	92.80	76.82
	5-Shandweel	11.9	7.1	24.9	14.6	18.2	11.8	74.17	80.51
	6-Mallawy	7.0	13.3	15.1	16.0	10.6	12.9	69.97	80.65
	7-Sids	12.7	8.2	31.2	13.9	24.9	10.9	79.93	78.27
3-Giza 843	1-Gemmiza	20.1	9.0	48.2	16.4	36.2	11.5	75.03	69.79
	2-Nubaria	14.4	11.6	32.9	27.6	26.7	21.5	82.10	77.88
	3-Giza	3.9	7.8	16.4	18.7	9.4	14.3	57.57	76.58
	4-Sakha	13.6	7.6	31.5	15.4	26.8	12.4	85.20	80.47
	5-Shandweel	6.8	6.7	24.5	13.9	18.3	10.7	75.13	77.62
	6-Mallawy	3.9	6.3	9.6	11.4	7.6	8.4	78.73	73.72
	7-Sids	12.1	5.5	30.7	9.8	23.5	7.3	76.80	75.19
LSD 0.05		1.8	1.3	2.8	2.2	3.1	1.9	9.35	6.28
C.V		9.4	15.1	6.2	13.1	9.0	14.5	8.04	5.07

Table 4. Cont.

Source of variance		Date of *Orobanche* emergence		No of *Orobanche* spikes /m^2		*Orobanche* dry weight (g.)/m^2	
		1st	2nd	1st	1st	2nd	1st
Cultivars (A)	**1-Giza 3**	**83.6**	**73.0**	**76.5**	**63.0**	**113.52**	**99.20**
	2-Misr 1	**71.4**	**77.1**	**38.2**	**23.9**	**64.96**	**42.99**
	3-Giza 843	**90.6**	**79.0**	**27.9**	**20.6**	**68.90**	**32.65**
L.S.D 0.05		**2.4**	**1.6**	**1.7**	**4.7**	**1.54**	**7.29**
Soils (B)	**1-Gemmiza**	**0.0**	**0.0**	**0.0**	**0.0**	**0.00**	**0.00**
	2-Nubaria	**112.2**	**104.3**	**27.4**	**23.4**	**79.97**	**78.38**
	3-Giza	**98.3**	**89.8**	**63.4**	**40.2**	**143.51**	**69.52**
	4-Sakha	**84.7**	**92.3**	**15.5**	**13.1**	**40.50**	**33.57**
	5-Shandweel	**98.5**	**85.4**	**81.3**	**76.9**	**123.76**	**100.19**
	6-Mallawy	**81.2**	**79.7**	**124.0**	**81.6**	**161.27**	**104.80**
	7-Sids	**98.2**	**83.0**	**21.1**	**15.7**	**28.22**	**21.50**
L.S.D 0.05		**2.2**	**1.7**	**2.5**	**6.3**	**3.33**	**8.26**
1-Giza 3	**1-Gemmiza**	**0.0**	**0.0**	**0.0**	**0.0**	**0.00**	**0.00**
	2-Nubaria	**106.5**	**93.7**	**51.7**	**44.4**	**159.00**	**158.50**
	3-Giza	**100.0**	**81.0**	**122.0**	**68.7**	**165.67**	**124.13**
	4-Sakha	**126.0**	**95.3**	**23.3**	**20.7**	**68.67**	**55.57**
	5-Shandweel	**85.5**	**84.0**	**144.3**	**141.9**	**174.00**	**171.43**
	6-Mallawy	**78.0**	**78.0**	**152.3**	**136.6**	**169.67**	**151.13**
	7-Sids	**89.0**	**97.0**	**41.7**	**28.8**	**57.67**	**33.63**
2-Misr 1	**1-Gemmiza**	**0.0**	**0.0**	**0.0**	**0.0**	**0.00**	**0.00**
	2-Nubaria	**115.0**	**104.0**	**18.8**	**16.7**	**67.33**	**66.87**
	3-Giza	**81.0**	**95.3**	**20.2**	**17.7**	**75.60**	**20.60**
	4-Sakha	**0.0**	**84.3**	**8.3**	**7.1**	**17.67**	**10.47**
	5-Shandweel	**110.5**	**86.0**	**62.3**	**49.9**	**98.33**	**84.10**
	6-Mallawy	**84.5**	**80.0**	**145.5**	**64.2**	**181.80**	**98.33**
	7-Sids	**108.5**	**90.0**	**12.3**	**12.1**	**14.00**	**20.57**
3-Giza 843	**1-Gemmiza**	**0.0**	**0.0**	**0.0**	**0.0**	**0.00**	**0.00**
	2-Nubaria	**115.0**	**115.3**	**11.7**	**9.1**	**13.57**	**9.77**
	3-Giza	**114.0**	**93.0**	**47.9**	**34.3**	**189.27**	**63.83**
	4-Sakha	**128.0**	**97.3**	**14.8**	**11.6**	**35.17**	**34.67**
	5-Shandweel	**99.5**	**86.3**	**37.4**	**38.9**	**98.93**	**45.03**
	6-Mallawy	**81.0**	**81.0**	**74.3**	**43.9**	**132.33**	**64.93**
	7-Sids	**97.0**	**80.0**	**9.3**	**6.1**	**13.00**	**10.30**
L.S.D 0.05		**3.8**	**2.9**	**4.4**	**10.9**	**5.76**	**14.30**
C.V		**2.8**	**2.4**	**7.8**	**18.4**	**5.96**	**14.79**

The highest mean No. of pods/plant was 12.2, 19.9 and 21.3 for genotypes, soils and interaction between them in the first season, respectively. No. of pods per plant decreased to 8.9, 8.8 and 13.3 for genotypes, soils and interaction between them in the second season, respectively. The maximum mean No. of seeds/plant, seed yield/ plant and

100 seed weight was recorded for genotype (Misr 1) 28.9, 22.80 g and 77.20 g, respectively in the first season and similar results for same characters were obtained for the same variety (Misr 1) 16.26, 13.16 g and 81.00 g, respectively in the second season. Gemmiza soil (free of *O.crenata*) gave the highest mean No. of seeds/ plant 47.3 and seed yield/ plant 36.50 g in the first season, whereas Sakha soil gave the highest mean no, of seeds/ plant 19.0 in the second season and 100 seed weight 82.87 g in the first season. The highest value of 100 seed weight recorded 92.80 g for interaction between genotypes and soil in the first season. The lowest mean of date of *Orobanche* emergence was 71.4, 81.2 and 78.0 in the first season and 73.0, 79. 7 and 78.0 in the second season for genotypes, soil and interaction between genotypes and soil, respectively. No of *Orobanche* spikes/m^2 gave the highest mean 76.5, 124.0 and 152.3 for genotypes, soil and interaction between them in the first season , while it was 63.0, 81.6 and 141.9 for genotypes, soil and interaction with them in the second season, respectively. The highest mean No. of *Orobanche* spikes/m^2 was at Mallawy soil (152.3) with variety Giza 3 in the first season for interaction between genotypes and soil. The lowest mean No. of *Orobanche* spikes/ m^2 was 15.5 and 13.1 for Sakha soil in the first and second season, respectively and these results are in agreement with No. of seed of *Orobanche*/Kg before planting in both season. *Orobanche* dry weight was recorded 113.52, 161.27 and 189.27 g in the first season and 99.20, 104.80 and 171.43 g in the second season for genotypes, soil and interaction between them, respectively. These results indicated that the two genotypes Misr 1 and Giza 843 were more tolerant to *Orobanche* than Giza 3 in these different soils naturally infested with O. *crenata*, so may be dissemination planting of these two genotypes in these sites with some agricultural practices to help the farmers of north and upper Egypt to return to planting of faba bean. These results are in agreement with those reported by Abbes *et al* (2007).

In Giza soil the susceptible cultivar Giza 3 had the lower mean value of *Orobanche* dry weight (165.67 g) than the tolerant cultivar Giza 843 (189.27g) at the first season. In this respect, Morsy and Attia (2002) reported that the susceptible cultivars (Giza 843 and Giza 3) had the lowest numbers and dry weight of *Orobanche* spikes per plot because of being dead early as a result of *Orobanche* infestation and the parasitic didn`t find supportive host and therefore died. On the other hand the susceptible cultivar Giza 3 had the highest level of infestation with high number of *Orobanche* spikes/m^2 (122.0, 68.7) at both seasons, respectively and *Orobanche* dry weight (124.13 g) at the second season only, these finding are in full agreement with those obtained by Ashrie *et al* (2010) who observed that Giza 40 cultivar possessed the highest level of infestation with high number and dry weight of *Orobanche* spikes/m^2, while the two tolerant genotypes, x01714 and x-1720 had the lowest No. of *Orobanche* spikes followed by Misr 1.

In Sakha soil, the greatest No. of *Orobanche* spikes/m^2 and *Orobanche* dry weight was observed in susceptible cultivar Giza 3 (23.3, 20.7) and (68.67, 55.57 g) at both seasons, respectively, while Misr 1 recorded the lowest No. of *Orobanche* spikes/m^2 and *Orobanche* dry weight (8.3, 7.1) and (17.67, 10.47 g) at both seasons, respectively. The tolerant cultivar Giza 843 had moderate No. of *Orobanche* spikes/m^2 and *Orobanche* dry weight (14.8, 11.6) and (35.17, 34.67 g) at both seasons, respectively. Similar results were found by Abd El-Maksoud *et al* (2007), El-Galaly *et al.* (2008), El-Degwey *et al* (2010) and Abd El-Aty *et al* (2016), who showed that susceptible parents possessed the highest level of infection with high No. of *Orobanche*/ plant, meanwhile the tolerant parents had the lowest No. of *Orobanche*/ plant.

The same pattern was found in Shandweel, Mallawy and Sids soils at both seasons. Ranking the cultivars according to No. of *Orobanche* spikes/m^2 and *Orobanche* dry weight at both seasons in descending order, cultivar Giza 3 ranked first (144.3,141.9) and (174.00,171.43) in Shandweel soil, (152.3,136.6) and (169.67, 151.13) in Mallawy soil, (41.7,28.8) and (57.67,33.63) in Sids soil, cultivar Misr 1 was the second (62.3,49.9) and (98.33,84.10) in Shandweel soil, (145.5,64.2) and (181.80,98.33) in Mallawy soil, (12.3,12.1) and (14.00,20.57) in Sids soil, while Giza 843 was the last (37.4,38.9) and (98.93,45.03) in Shandweel soil, (74.3,43.9) and (132.33, 64.93) in Mallawy soil, (9.3,6.1) and (13.00,10.30) in Sids soil.

Results in (Table 4) showed that the tolerant cultivar Misr 1 had lower No. of *Orobanche* spikes/m^2 (8.3, 7.1) and *Orobanche* dry weight (g) /m (17.67, 10.47) than tolerant cultivar Giza 843 (14.83, 11.60) and (35.17, 34.67) in Sakha soil at both seasons, respectively. These results are in harmony with those previously obtained by El-Degwey *et al* (2010), El-Halmouch and Ghalwash (2009). In this respect, Ismail (2008) found that variety Misr 1 decreased the number and dry weight of broomrape spikes/m^2 as compared with Giza 40 variety. It is suggested that the promotion of resistance may be attributed to one or more of the following factors: No. production of stimulant or production of inhibitors, dilution or wash of stimulant by excess water I the rhizosphere, difficulty in translocation substances from the host plant where its osmotic pressure is very high, difficulty of penetration of the haustorium into the host root, based on lignifications or mechanical barriers formation. These results are in line with those obtained by El-Sayed *et al* (2003) and Soliman *et al* (2011). Abdalla *et al* (2006) reported that the performance of genotypes differed from location to another and none of the selected materials or genotypes could be recommended as a variety for all locations

On the other hand, in Mallawy and Shandweel soils susceptible cultivar Giza 3 recorded the lowest mean value of No. of seeds/plant and seed yield/plant as compared to tolerant cultivars, these results are in agreement with those obtained by Ismail (2008), Soliman *et al* (2011) and Soliman *et al* (2012).

Genetic variability and heritability

In the present study, high phenotypic coefficient of variation (PCV) was observed for No. of pods/plant (31.9%), No. of seeds/plant (29.8%), seed yield/plant (31.9%) ,date of *Orobanche* emergence (33.9%), No. of *orobanche* spikes/m^2 (65.1%) and *Orobanche* dry weight (52.9%) in the first season, while it was observed for date of *Orobanche* emergence (27.8%) and No. of *orobanche* spikes/m^2 (55.7%) in the second season (Table 5). Medium PCV were observed for plant height (14.9%),height of first pod (21.7%), No. of branches/ plant (22. 1%) and 100 seed weight (14.0%) in the first season, whereas it was medium for height of first pod (17.6%), No of branches/plant (14.3%),No. of pods/plant (18.9%), No. of seeds/plant (22.7%), seed yield/plant (23.5%), 100 seed weight (14.1%) and *Orobanche* dry weight (20.4%) in the second season. The results more or less agreed with those reported by Mulualem *et al* (2013). As reported previously by other investigators like Ulukan *et al* (2003), Alghamdi (2007) and Bakhiet *et al* (2015) the genetic variance components in traits such as seed yield, No. of pods, seeds seed weight/ plant , 100 seed weight and plant height, played an important role in the total variation(Table 5). High genotypic coefficient of variation (GCV) was observed for No. of pods / plant (29.9%), No. of seeds/plant (28.7%), seed yield/plant (30.7%), No. of *orobanche* spikes /m^2 (57.1%) and Orobanche dry weight (46.5%) in the first season. Moderate (GCV) were estimated for No. of branches/ plant (20.0%) and date of *Orobanche* emergence (26.7%) in first season, whereas it was observed in seed yield/ plant (15.0%) and *Orobanche* dry weight (16.1%) in second season. Similar results were reported by several authors such as El-Hosary and Nawar (1984), Mahmoud and Al- Ayobi (1986) and Bakheit *et al* (2015). Low GCV was observed for 50% flowering (0.6), 90% maturity (3.7), plant height (2.9), height of first pod (5.1) and 100 seed weight g(3.8) in the first season, while it was observed for 50% flowering (0.6), plant height (1.4), height of first pod (6.1), No. of branches/ plant (6.2) No. of seeds/plant(12.4) and 100 seed weight (2.9) in the second season. High GCV value of characters suggested the possibility of improving these traits through selection. Similarly, El- Hosary and Nawar, (1984) estimated different levels of GCV in faba bean. Moreover, the differences between PCV and GCV were very small which indicated the importance of genetic variance in the inheritance of the studied characters.

Table 5. Estimates of heritability, genetic advance, GCA,PCV for characters in seasons 2014/2015 and 2015/2016.

Parameters	50% Flowering		90% Maturity		Plant height		First pod height		No. of branches/ plant		No. of pods/plant	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
∂g	0.1	0.1	25.5	-11.4	6.1	1.4	1.3	1.9	0.3	0.0	11.8	-0.5
∂ph	0.2	0.2	349.9	338.1	159.5	92.9	23.9	15.8	.0.3	0.1	13.4	1.9
h^2	67.4	42.0	7.3	-3.4	3.8	1.5	5.5	11.9	82.1	18.8	88.1	-28.2
GCV	0.6	0.6	3.7	-	2.9	1.4	5.1	6.1	20.0	6.2	29.9	-
PCV	0.8	0.9	13.6	13.2	14.9	11.3	21.7	17.6	22.1	14.3	31.9	18.9
GA	0.5	0.4	2.8	-1.3	0.9	0.3	0.6	0.9	0.9	0.1	6.7	-0.8
GA%	1.1	0.8	2.1	-0.9	1.2	0.3	2.4	4.3	37.4	5.5	57.9	-11.0
Parameters	**No. of seeds/ plant**		**Seed yield/plant**		**100-Seed weight**		**Date of *Orobanche* emergence**		**No of *Orobanche* spikes /m²**		***Orobanche* dry weight**	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
∂g	62.9	3.1	41.5	2.8	7.5	4.2	477.5	508.5	735.7	371.4	1468.1	556.0
∂ph	67.6	10.3	44.8	6.9	100.2	101.2	770.1	519.5	957.9	528.8	1899.5	889.0
h^2	93.0	29.9	92.9	40.7	7.5	4.2	62.0	97.9	76.8	70.2	77.3	62.5
GCV	28.7	12.4	30.7	15.0	3.8	2.9	26.7	27.6	57.1	46.7	46.5	16.1
PCV	298	22.7	31.9	23.5	14.0	14.1	33.9	27.8	65.1	55.7	52.9	20.4
GA	15.8	1.9	12.8	2.2	1.6	0.9	35.4	45.9	48.9	33.3	69.4	38.4
GA%	57.1	14.0	60.9	19.7	2.2	1.2	43.3	56.2	103.0	80.6	84.2	26.3

Heritability (h^2) in broad sense estimates were generally high for most studied traits which ranged from 30 to 93 for No. of seeds/plant in the second and first season, respectively. The highest estimate of broad sense heritability (h^2) was recorded for days to 50% flowering, No. of branches/plant, No. of pods/plant, No. of seeds/plant , seed yield/plant g, date of *Orobanche* emergence, No. of *Orobanche* spikes and *Orobanche* dry weight g/m^2 with heritability of 67, 82, 88, 93, 93, 62, 77 and 77, respectively in first season while it was recoded 42 , 41, 98, 70 and 63 for days to 50% flowering, seed yield/ plant (g), date of *Orobanche* emergence, No. of *Orobanche* spikes/m^2 and *Orobanche* dry weight g/m^2, respectively in the second season. No. of seeds/plant and seed yield/ plant in the second season showed medium heritability (30%) and (41%), respectively, which makes selection for these traits difficult because environmental effect is more evident than genetic effect. However, Dixit *et al* (1970) reported that high heritability and GCV were not always associated with high genetic advance. Meanwhile, Swarup and Changle, (1962) reported that both heritability ratio and GCV% gave the best picture for the expected genetic advance. The trait that showed high and moderate heritability was found to have high GCV value than trait that showed low heritability. Selection for these traits is relatively easy because most of the variation is genetic rather than environmental. On the other hand, traits with high PCV have less heritability which means variation for these traits is more environmental than genetic and it is not advisable to select for these traits. Dabholkar (1992) explained that whenever values are stated for heritability of a character, it refers to a particular population under particular environmental conditions. Accordingly, all the agronomic characters considered for analysis showed high heritability, constituting high breeding value which has more additive genetic effects which is important for crop improvement. Heritability, which measures phenotypic variance and is attributable to genetic causes, is another important consideration for a successful breeding program.

The expected genetic gains from selecting the top 5% of the characters under study as a percent of the mean was 37.4, 57.9, 57.1 and 60.9% for No. of branches/plant , No. of pods/plant , No. of seeds/plant and seed yield / plant in the first season, respectively. The high values of genetic advance for most studied traits with high heritability estimates were recorded and should be considered simultaneously for their improvement through selection. The expected genetic advance recorded 43.3 and 56.2% for date of *Orobanche* emergence in first and second season, respectively, while it recorded 103.0 and 80.6% for No. of *Orobanche* spikes/m^2 in first and second season, respectively and recorded 48.2 and 26.3% for *Orobanche* dry weight g/m^2 in first and second season, respectively. The expected genetic advance for No. of *Orobanche* spikes/m^2 in first in the first season was more than 100% because genetic advance (48.97) more than general mean of this character (47.5).

The low values of expected genetic advance were recorded for date of 50% flowering, date of 90% maturity, plant height, height of first pod and 100 seed weight (g) in first and second season, while it was low for No. of branches/plant, No. of pods/plant, No. of seeds/plant and seed yield/plant (g) in the second season (Table 5). The low values of expected genetic advance for some characters were due to low variability for the traits indicated by the medium GCV and PCV values. Therefore, even if heritability estimates provide basis for selection on phenotypic performance, the estimates of heritability and genetic advance should always be considered simultaneously, as high heritability is not always associated with high genetic advance. These results are in agreement with those obtained by Bakhiet *et al* (2015).Presence of genetic variability and heritability estimates would be helpful to the breeder to estimate genetic advance and to predict percentage of genetic advance in the population under study. Success of genetic improvement is attributed to the magnitude and nature of variability present for specific character. Accordingly all the agronomic characters considered for analysis showed high heritability, constituting high breeding value which has more additive genetic effects which is important for crop improvement. Similar results were reported by El-

Hosary and Nawar (1984); Mahmoud and Al Ayobi (1986) and Mulualem *et al* (2013).

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التباين لتحمل بعض أصناف الفول البلدى للهالوك
تحت العدوى الطبيعية للتربة

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١. قسم بحوث المحاصيل البقولية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

٢. المعمل المركزى لبحوث الحشائش – مركز البحوث الزراعية – جيزة– مصر

اجريت هذه الدراسة بمحطة البحوث الزراعية بالجميزة– مركز البحوث الزراعية خلال موسميين ٢٠١٥/٢٠١٤، ٢٠١٦/٢٠١٥ لتحديد التباين الوراثى والمظهرى والمكافىء الوراثى والتطور الوراثى لصفة المحصول والمقاييس المرتبطة بها لثلاثة أصناف (جيزة ٣، مصر١،جيزة ٨٤٣) تم زراعتها فى ستة أنواع مختلفة من التربة المصابة طبيعيا بالهالوك جمعت من مزارع المحطات البحثية (شندويل– ملوى– سدس– جيزة– نوبارية – سخا) مقارنة مع تربة مزرعة الجميزة الخالية من الهالوك فى الليزومترات . مساحة الليزوميتر ٢X١ = ٢م^{٢} وارتفاعها ١،٥ م . تم تحديد بذور الهالوك بصريا باستخدام الميكروسكوب . أوضح تحليل التباين للصفات المدروسة ان هناك اختلافات معنوية بين الأصناف والتربة والتفاعل بينهما. كانت قيمة المكافىء الوراثى ٦٧,٤% لصفة ٥٠% تزهير ، ٨٢,١% لعدد الفروع / النبات ، ٨٨,١% لعدد القرون / النبات ، ٩٣,٠% لعدد البذور / النبات ، ٩٢,٧% لمحصول البذور / النبات ، ٩٧,٩% لميعاد ظهور أول شمراخ هالوك، ٧٦,٨% لعدد شماريخ الهالوك / م^{٢} ، ٧٧,٣% للوزن الجاف لشماريخ الهالوك جم / م^{٢}. اوضحت الدراسة ان القيم العالية للتقدم الوراثى بالإنتخاب لمعظم الصفات تحت الدراسة مع كفاءة التوريث العالية تساعد المربى فى انتخاب سلالات متحملة للإصابة بالهالوك.أوضح التحسين الوراثى المتوقع من انتخاب اعلى ٥ % من الصفات تحت الدراسة كانت ٣٧,٤٠، ٥٧,٩٢ ، ٥٧,٠٥ ، ٦٠,٨٩ لصفات عدد الفروع / النبات ،عدد القرون / النبات ، عدد البذور / النبات ، محصول البذور / النبات جم . أوضحت النتائج ان قيم المكافىءالوراثى العالية بالاضافة للتطور الوراثى العالى لصفة محصول البذور / النبات وان هذه الصفة يتحكم فى توريثها الفعل الجينى المضيف.

المجلة المصرية لتربية النبات ٢٠(٥) :٨٥١- ٨٦٧ (٢٠١٦)