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INHERITANCE ASSESSMENT OF CHOCOLATE SPOT AND RUST DISEASE TOLERANCE IN MATURE FABA BEAN (*VICIA FABA* L.) PLANTS

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Abstract

The major aim for any crop breeding program is the development of good quality lines with an adequate resistance/tolerance to yield-reducing stresses. Fungal diseases i.e., chocolate spot (*Botrytis fabae* Sard) and rust (*Uromyces fabae* (Pers.) Schart) are the most destructive diseases of faba bean and cause considerable dramatic damage losses on faba bean yield worldwide. Therefore, the use of breeding efforts by studying the mode of inheritance of resistance to both diseases (chocolate spot and rust) in *Vicia faba*, give evidence for the existence of one or more genes controlling the resistance of these diseases. Identifying the mode of inheritance of field resistance to chocolate spot (*B. fabae*) and rust (*U. fabae*) diseases in *Vicia faba* at the adult plant stage was considered in this work. The F_1's, F_2's and F_3's off-spring of resistant and susceptible faba bean plants were assessed under natural infection in a private field in Ismailia Governorate, Egypt, from the period of mid October to mid April in two successive sesaons (2007/08 and 2008/09). The faba bean plants were evaluated for the resistance to chocolate spot (*B. fabae*) and rust (*U. fabae*) diseases at maturity stage using a five-class scale of increasing susceptibility to the disease, which took into account the number of infected leaves and the size of the sporulating lesions. The results exhibited that the F_1's was completely resistant to both the diseases, the F_2's segregated a clear 3 resistant: 1 susceptible, while the F_3's confirmed the F_2's segregation, which suggests that a dominant character controlled by a single locus. This resistance has well potencial for direct use in commercial faba bean breeding or for transfer to other faba bean gemplasm.

Introduction

Faba bean (*Vicia faba*) is one of the major pulse crops grown in Egypt and many countries. Its recorded history in Egypt returned back to 1580 B.C (Abdalla, 1979). It is a multi-purpose crop that plays an important role in the socio-economic life of farming communities (Agegnehu & Fessehaie, 2006). It serves as a source of food, feed and is a valuable cheap source of protein and is influenced by stress (Noorka *et al.*, 2009) In addition, it is an excellent candidate crop to provide nitrogen input into temperate agricultural systems, moreover, it makes a significant contribution to soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen (Samuel *et al*., 2008).

In spite of its great importance, the productivity of faba bean in Egypt is still far below the crop's potential (>3tha^{-1}). Some biotic and abiotic factors are the main reason of the low productivity of faba bean (Agegnehu *et al.*, 2006). Diseases are among the important biotic constrains that limit the production of faba bean crop. Chocolate spot (*Botrytis fabae* Sard.) and rust (*Uromyces fabae* (Pers.) Schart) are one of the economically important diseases that damage the foliage, limiting photosynthetic activity and reduce faba bean production (Bretag & Raynes, 2004, Bouhassan *et al*., 2004, Torres *et al*., 2006, Awaad *et al*., 2005 and El-Bramawy & Abdul Wahid, 2005).

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In the Middle and Near east, losses due to both diseases reach about 60 - 80 % in case of chocolate spot disease (Dereje & Yaynu, 2001, Herath, 2001 and Bouhassan *et al*., 2004) and 50 -70 in case of rust disease (Stoddard & Herath, 2001, Avila *et al*., 2003) on susceptible cultivars. They may also, cause total crop failure under severe epidemic conditions (Yu *et al*., 1998, Torres *et al*., 2006; El-Bramawy & Abdul Wahid, 2005).

The chocolate spot disease (*B. fabes*) occurs mainly on leaves, but stems and flowers may also be infected under sever conditions. Under optimum conditions of temperature (18-20^{o}C) and relative humidity (90-100%), the pathogen becomes aggressive. Also, under prolonged wet conditions, the disease may be epidemic with heavy crop losses (Bernier *et al*., 1993). The spots on leaves and stems enlarge and develop a grey, dead centre with a red-brown rim or margin. Chocolate spot can kill flowers and stems. Spores will form on this dead tissue. Damage caused by red-legged earth mite can be mistaken for chocolate spot. This starts as silvery patches which become red-brown, similar in colour to chocolate spot but form large irregularly-shaped areas. Red-legged earth mite damage usually occurs during the seedling stage and on the lower leaves.

On the other hand, the rust disease (*U. fabes*), occurs on the leaves where numerous, small, orange-brown pustules, each surrounded by a light yellow halo, are observed symptoms which first appear as minute, slightly raised, white to cream colored spots on leaves and to a lesser extent on stems. As spots enlarge the epidermis ruptures, releasing masses of brown spores (urediospores) to form characteristic pustules (uredia). The pustules are often surrounded by a ring of yellow tissue. On highly susceptible cultivars, the disease can build up rapidly until most of the leaves are covered with pustules. Infected leaves rapidly wither, dry up and premature defoliation may occur. On stems, the rust pustules are similar, but often larger than those on the leaves. Isolated rust pustules may also appear on the pods. Severe infection may cause premature defoliation, resulting in reduced seed size.

The potential loss of effective fungicides has created strong incentives to develop effective alternative methods for tolerance or resistance each of chocolate spot and rust diseases. Therefore, the use of resistant cultivars of the crop is considered the most desirable control method. It provides a practical, long-term, and environmentally friendly benign means of limiting the damage from the diseases (Wang *et al*., 2001). The most studies, which carried out on the resistance to foliar diseases (chocolate spot and rust) in faba bean crop have concentrated on just evaluation or assessment of the resistance to diseases for some faba bean genotypes under diseased conditions. But, very rarely studies were done on the inheritance of the diseases resistance, therefore, it's urgently to focus on this approach for obtaining resistance varieties of faba bean with high potential seed yield, especially under natural field conditions.

In general, field resistance of the plants is actually commercially very important, however, it received less attention than green house resistance. There are several sources of resistance to *Botrytis fabae* (chocolate spot) and *Uromyces fabae* (rust) with little differences through these conditions. The type of inheritance varies with the source of resistance, for example, one single gene was found in broccoli and cauliflower (Natti *et al*., 1967), while two dominant, independent genes were detected in Torched cabbage (Carvalho & Monteiro, 1996). Two or three dominant genes were observed in cauliflower (Moss *et al*., 1988) and three to four dominant complementary genes in broccoli and cabbage (Hoser- Krauze *et al*., 1995). Although some resistances have been reported at early stage (i.e. seedling stage) hold up through maturity stage, the seedling stage resistance cannot be used to predict adult-plant resistance, because there is no clear correlation between the two types of resistance (Coelho *et al*., 1998). On the other hand, there are several authors who have studied the resistance to chocolate spot disease (*B. fabae*) of faba bean (Tivoli *et al*., 2006; Samuel *et al*., 2008), while others studied the resistance to(U fabae) rust disease (Sillero *et al*., 2000; Avila *et al*., 2003). But (Awaad *et al*., (2005) and El-Bramawy & Abdul Wahid (2005) studied the resistance to both diseases of faba bean crop. The data collected during the above mentioned studies were taken at early time before flowering of the faba bean genotypes. However, Dickson & Petzoldt (1993) suggested that assessment or testing for the plants should be better to evaluate for disease resistance after mature plant stage.

The purpose of the present investigation was to determine the mode of inheritance of the resistance to chocolate spot disease (*B. fabae*) and rust disease (*U. fabae*) in faba bean crop and to assess its breeding value.

Material and Methods

Genetic populations background for parental materials: The six faba bean parents used in this work were selected from a 20 fabe bean genotypes evaluated previously under natural infection by foliar pathogens disease (*Botrytis fabae* Sard, chocolate spot and *Uromyces fabae* (Pers.) Schart, rust). This previous evaluation was done at the field of the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt through seasons 2003/04 & 2004/05 (El-Bramawy & Abdul Wahid, 2005). The background of the 20 faba bean genotypes names and their pedigree history as well as the earliness character and seed yield (g/plant) are presented in Table 1. The results of the previous evaluation for the behavior of the 20 faba bean genotypes with the both fungal pathogens (*Botrytis fabae* and *Uromyces fabae*) are presented in Table 2.

Determination parental selection: According to data of Table 2, two genotypes were selected on the basis of two opposite factors. First factor was the highest infection and percentage of severity, while second factor was the lowest infection and percentage of severity. Therefore in this respect, the genotype BPL 710 which had ranked as a resistance parent (R), parent no. 20 (P6) and the genotype Giza 402, which was scored as susceptible parent (S), parent no. 2, (P_2) were selected (Table 2). Giza 402 as a susceptible cultivar (Awaad *et al*., 2005; El-Bramawy & Abdul Wahid, 2005) and BPL 710 cultivar as a resistant host (Santorelli *et al*., 1992, El-Bramawy & Abdul Wahid, 2005).

Parental cross and obtaining generations: The faba bean genotypes of the two parents (BPL 710 & Giza 402) were selfed three times, retested at the field between each generation of selfing, and the resulting S_3 individuals used as resistant (R) and susceptible (S) faba bean parents. The resistant (BPL 710) and susceptible (Giza 402) cultivars were crossed to obtain F_1 hybrids (First generation, F_1's). Then ten F_1 individuals from two different parental hybrids were selfed to give the F_2 populations (Second generation, F_2's). Twenty-six resistant or susceptible F_2 individuals, from four different generations, were selfed to produce F_3 populations (Third generation, F_3's). These hybridizations for obtaining the three generations (F_1's, F_2's and F_3's), were carried out through seasons, 2005/06, 2006/07 and 2007/08, respectively in the Experimental Farm, Fac. of Agric., Suez Canal Univ., Ismailia, Egypt.

Table 1. Faba bean genotypes, pedigree history, earliness (days to 50% flowering) and seed yield (g/plant).

No.	Genotypes name	Pedigree	Earliness	Seed yield (g/plant)
1.	Giza 2	Individual plant selection from land races	58.32	20.29
2.	Giza 3	Cross (Giza 1 x N A 29)	50.23	23.62
3.	Giza 40	Individual plant selection from Rebaya 40	58.29	27.09
4.	Giza 429	Individual plant selection from Giza 402	52.10	33.98
5.	Giza46l	Cross (Giza3 x 1LB938)	50.13	37.18
6.	Giza 643	Cross (249 *I* 84 / 80 x NA 83)	52.69	28.24
7.	Giza 674	Cross (F - 4..2 x B P L 982)	64.25	25.68
8.	Giza7l4	Cross (462B1 908/83/503/453/ 83	52.12	31.02
9.	Giza 716	Cross (461 1842183 *x5031* 453/83 x I L B 938	58.05	26.21
10.	Giza 843	Cross (561 *I* 2-76 /85 x 461 *I* 845 / 83	53.02	29.26
11.	Rena blanca	Not available	65.87	31.21
12.	Sakhal	Cross(7161924/88 x 620/283/81)	49.21	38.59
13.	Sakha 2	Cross (Rena Blanka x 461 / 845 / 85)	55.45	28.33
14.	Misre 1	Cross (Giza 3 x 123 A /45 / 76	57.25	20.00
15.	Miser 2	Individual plant selection from Youssef EI-Sedek	50.23	20.02
16.	Moshtohor 103	Not available	67.05	30..31
17.	Trible White	Individual plant from sudanese selection	54.26	31.58
18.	Nubaria 1	Individual plant selection from Giza Blanka.	65.00	32.11
19.	Giza 402	Individual plant selection from Land races	62.28	14.89
20.	BPL 710	NA, Introduce from Clombia.	48.02	37.41

Table 2. Mean performance for faba bean genotypes for the studied traits during two successive seasons (2003/04 & 2004/05).

Characters Genotypes	Earliness		Chocolate spot						Rust						Seed yield/ plant (g/plant)	
			Infection	Rank	Severity %	Infection	Rank	Severity %	Infection	Rank	Severity %	Infection	Rank	Severity %		
	2003	2004	2003			2004			2003			2004			2003	2004
Giza 2	55.28	58.32	6	MR-S	7	8	S-HS	9	7	S	8	8	S-HS	9	21.66	20.29
Giza 3	49.67	50.23	7	S	8	7	S	8	7	S	8	7	S	8	20.86	23.62
Giza 40	60.20	58.29	3	R	1	3	R	1	4	R-MR	2.5	4	R-MR	2.5	24.21	27.09
Giza 429	52.90	52.10	5	MR	4	3	R	1	5	MR	4	3	R	1	30.17	33.98
Giza 461	48.99	50.13	4	R-MR	2.5	4	R-MR	2.5	3	R	1	2	HR -R	1	32.12	37.18
Giza 643	54.32	52.69	3	R	1	4	R-MR	2.5	3	R	1	5	MR	4	35.11	.28.24
Giza 674	65.02	64.25	6	MR-S	7	4	R-MR	2.5	7	S	8	7	S	8	.22.01	25.68
Giza 714	55.00	52.12	5	MR	4	5	MR	4	5	MR	4	5	MR	4	27.13	31.02
Giza 716	57.58	58.05	6	MR-S	7	4	R-MR	2.5	5	MR	4	4	R-MR	2.5	23.63	26.21
Giza 843	54.09	53.02	5	MR	4	5	MR	4	5	MR	4	5	MR	4	25..01	29.26
Rena blanca	67.01	65.87	4	R-MR	2.5	4	R-MR	2.5	3	R	1	3	R	1	28.45	31.21
Sakha 1	47.25	49.21	3	R	1	2	HR-R	1	3	R	1	2	HR-R	1	37.12	38.59
Sakha 2	56.25	55.45	3	R	1	3	R	1	4	R-MR	2.5	6	MR-S	7	31.16	28.33
Misre 1	56.23	57.25	7	S	8	5	MR	4	8	S-HS	9	8	S-HS	9	19..23	20.00
Miser 2	52.01	50.23	8	S-HS	9	6	MR-S	7	8	S-HS	9	6	MR-S	7	25.35	20.02
Moshtohor 103	64.14	67.05	5	MR	4	5	MR	4	5	MR	4	5	MR	4	26.18	30..31
Trible white	55.02	54.26	5	MR	4	3	R	1	6	MR-S	2.5	4	R-MR	2.5	26.19	31.58
Nubaria 1	66.12	65.00	4	R-MR	2.5	4	R-MR	2.5	3	R	1	3	R	1	29.29	32.11
Giza 402	59.13	62.28	7	S	8	8	S-HS	9	9	HS	10	9	HS	10	13.68	14.89
BPL 710	47.20	48.02	3	R	1	3	R	1	1	HR	Scarce	1	R	1	34.15	37.41
L S D at 0.05%	1.56	1.22	1.42	-	1.75	1.10	3	1.76	1.91		2.08	1.47		2.09	1.17	1.61
L S D at 0.01%	2.09	1.63	1.90		2.34	1.47		2.36	2.56		2.79	1.94		2.81	1.56	2.15

HR = Highly Resistant, R = Resistant, MR = Moderately Resistant, S = Susceptible, HS = Highly Susceptible Earliness = days to 50% flowering.

Field testing of resistance and Experimental design: The experiment was laid out in the field during October 2008/09 and 2009/010 at the Experimental Research Station of the Faculty of Agric., Suez Canal Univ., Ismailia, Egypt, followed by Noorka *et al*., (2007). The seeds of F_1's, F_2's and F_3's faba bean generations plants were sown in four ridges (F_1's), ten ridges (F_2's), and twenty ridges (F3's), 5 m long and 60 cm width, with single seed per hill and a spacing of 20 cm between hills following a randomised complete block design, with three replications. The faba bean plants grown, following the current local commercial practices including sprinkler irrigation, manual weeding and top dressing with ammonium nitrate in order to ensure healthy plant growth. No chemical treatments were applied to the plants during the field assay. Besides the natural climatic conditions favouring chocolate spot (*B. fabae*) and rust (*U. fabae*) of the crop consider, natural infection in the field was encouraged by sprinkler irrigation before sunset and intercropping with plants of a susceptible faba bean (*V. faba*) inbred to serve as disease spreaders and to promote a high level of disease pressure in the field considering the research work.

Estimation of the resistance in fields: To estimate and account for eventual differences in diseases stress development, the resistant and susceptible parents were selfed. The 54 resistant and the 54 susceptible S4 individuals were tested in the field to confirm that there was no segregating for resistant or susceptibility. At planting, the seedlings of F_1's, F_2's and F_3's faba bean population were split into three equal groups and each group was assigned to a different block. The total number of tested plants were 60 F_1's, 450 F_2's and 630 F_3's plants. Each plant was evaluated twice, before flowering stage and at harvest stage, using the interaction phenotype classes, which described by Coelho *et al*., (1998) with little pit modification to be more suitable for the present work. This modified scale is presented in Table 3. This scale was taken into account of the intensity (size of the lesions) and the progression (number of infected leaves) of infection in each of chocolate spot and rust diseases separately. When there was a difference between the first and the second evaluation, the highest score was considered. The faba bean plants of F_1's and F_2's in classes 0 and 1 were ranked as resistant (R) plants, the faba bean plants in classes 2, 3 and 4 scored as susceptible (S) plants. On the other hand, the faba bean plants of F_2's, families were just evaluated as resistant (R) plants or susceptible (S) plants without the use of the 0–4 interaction-phenotype class scale as shown in Table 3, (Coelho *et al*., 1998).

Statistical analyses: Chi-square test was used to determine goodness of fit to hypothesized models based on observed (O) and expected (E) numbers of resistant (R) and susceptible (S) individuals plants in each of F_2's and F_3's populations.

Results

Data of faba bean segregation for field resistance to chocolate spot (*B. fabae*) and rust (*U. fabae*) in the F_1 hybrids and the ten F_2 populations are presented in Tables 4 & 5, respectively. The F_1's hybrids, resulting from the crossing between the resistant (R) cultivar "BPL 710" and the susceptible (S) "Giza 402" parents (R x S) exhibited uniformly resistant (R) under infection of chocolate spot (*B. fabae*) and rust (*U. fabae*), respectively. On the other hand, the all ten F_2's populations segregated at a ratio of 3 resistant: 1 susceptible (3 R: 1 S). Hence, when all individuals of F_2's were adapted to chi-square analysis they indicated a very close fit to the 3 R: 1S ratio (p = 0.96) (Table 4

& 5). While, the F_3's generation, which resulted from the resistant F_2 plants were either uniformly resistant or segregated to 3 resistant: 1 susceptible (3 R: 1S). These ratios distinguishing the homozygous in comparing the heterozygous F_2 parent. The same trend was noticed in case of chocolate spot (*B. fabae*) and rust (*U. fabae*) as shown in Tables 6 and 7. Also, it can be noted, according to the present results, that the only exception cases in this work with *B. fabae*, were the susceptible F_3's families, number 14 and number 21 (Table 6). While, with *U. fabae*, the exception was only the susceptible F_3's family number 23 as shown in Table 7. Some F_3's families of *V. fabea* plants showed low degree of resistance, these were numbers 1, 2, 10, 19, 20 and 24 (Table 6), in case of chocolate spot (*B. fabea*) disease and numbers 1, 7, 13, 16, 19, 20 and 24 (Table 7), in case of the rust disease (*U. fabae*).

Discussion

Faba bean plants are challenged by many fungal pathogens, such as *Botrytis fabae* Sard (chocolate spot disease) and *Uromyces fabae* (Pers.) Schart (rust diseases), which strongly affect crop yield worldwide. Genetic resistance is considered the most desirable control method since it is more cost effective and environment friendly than the use of chemicals. Thus, many resistance sources and their associates have been found in different legumes including faba bean (Sillero *et al*., 2006 and Torres *et al*., 2006). The common lack of dominant trend attitudes of inheritance and the general lack of knowledge about inheritance of resistance mechanisms in legumes including faba bean limit greatly the use of genetic recourses. Therefore, they offer a great opportunity to improve the knowledge in resistance inheritance mechanisms against faba bean pathogens and identify effective resistance genes against them.

The susceptible cultivar Giza 402 was used earlier as indicator susceptible host, check cultivar (Abo El-Zahab *et al*., 1994, Awaad *et al*., 2005 and El-Bramawy & Abdul Wahid, 2005). Also, the other parent (BPL 710), which was selected as resistance was detected before as a resistant cultivar in previous work by several investigators (Santorelli *et al*., 1992, El-Bramawy & Abdul Wahid, 2005). This supports the selection of both parents (BPL 710, R and Giza 402, S) to be a basic materials in this work. Several sources of resistance to each of *Botrytis fabae* (chocolate spot) and *Uromyces fabae* (rust) at mature plant stage in *Vicia faba* have been found (Bretag & Raynes, 2004, Bouhassan *et al*., 2004, Torres *et al*., 2006; Awaad *et al*., 2005, El-Bramawy & Abdul Wahid, 2005; Bernard *et al*., 2006), but no one of these were genetically characterized. In other crops cases, a broccoli line in a homozygous state for resistance ('P.I.189028') with anther completely susceptible broccoli, producing resistant hybrids in all instances. Then progeny evaluated under greenhouse conditions of the F_2's resulting from this F_1's showed clearly a ratio of segregation, 3 resistant to 1 susceptible at seedling stage. The finding indicating that the resistance is conditioned by a single dominant gene. Also, Mahajan *et al*., (1995) reported a single dominant gene governing downy mildew field resistance of adult-plants in one cross of cauliflower, but in another cross results indicated a recessive epistasic inheritance. Coelho *et al*., (1998) identified a new source of resistance to downy mildew in mature plants of broccoli in a field screening in Portugal, while,Rhaiem *et al*., (2002) identified new faba bean genotypes resistant to chocolate spot caused by Botrytis fabae, in Tunisie Silleroa *et al*., (2000) explained the characterization of the new sources of resistance to *Uromyces fabae* in a germplasm collection of *Vicia faba* in Spain.

Table 3. Chocolate spot (*Botrytis fabae*) or rust (*Uromyces fabae*) interaction-phenotype classes for field evaluation of faba bean plants

No.	Class	Chocolate spot (*B. fabae*) and or rust (*U. fabae*) diseases interaction phenotype	Rank
1	0	No host response, no sign of infection	Resistant (R)
2	1	One leaf with a few large, sporulated lesions or only one to two leaves with small, sporulated lesions	Moderately resistant (MR)
3	2	Two leaves with large, sporutated lesions or at least three leaves with small, sporulated lesions	Susceptible (S)
4	3	Three to four leaves with large, sporulated lesions plus a variable number of leaves with small, sporulated lesions	Moderately susceptible (MS)
5	4	Five or more leaves with large, sporulated lesions	Highly susceptible (HS)

Small lesions ≤ 1cm2 and large lesions > 1cm2. (Adapted from Coelho *et al.* (1998).

Table 4. Faba bean Segregation for field resistance to chocolate spot (*Botrytis fabae* Sard) in the F_1 hybrids and the ten F_2 populations.

Cross	Observed plant	IP class					Observed ratio R : S	1 Gene hypothesis	$\chi 2$	p-value
		0	1	2	3	4		Expected ratio R : S		
F_1^*	33	33	-	-	-	-	33: 0	1: 0 (33: 00)	-	-
F_1^*	27	27	-	-	-	-	27: 0	1: 0 (27: 0)	-	-
F_2	53	38	6	4	4	1	44: 9	3: 1 (39.75: 13.25)	1.817	0.212
F_2 [a]	43	27	5	3	7	1	32: 11	3: 1 (32.25: 10.75)	0.006	0.943
F_2 [b]	41	24	4	7	4	2	28: 13	3: 1 (30.75: 10.25)	0.983	0.482
F_2	43	29	4	3	7	-	33: 10	3: 1 (32.5: 10.50)	0.032	0.451
F_2	49	33	2	6	5	3	35: 14	3: 1 (36.75: 12.25)	0.333	0.284
F_2 [c]	44	21	8	8	4	3	29: 15	3: 1 (33.00: 11.00)	1.939	0.451
F_2 [d]	45	28	6	3	8	-	34: 11	3: 1 (33.75: 11.25)	0.007	0.772
F_2	53	31	5	8	8	1	36: 17	3: 1 (39.75: 13.25)	1.444	0.134
F_2	34	22	6	3	2	1	28: 6	3: 1 (25.5: 8.50)	0.980	0.441
F_2	45	31	5	7	2	-	36: 9	3: 1 (33.75: 11.25)	0.600	0.374
F_2 Total	450	284	51	52	51	12	335: 115	3: 1 (337.75: 112.25)	0.089	0.961

F_1 from a resistant × susceptible cross.
a, b, c, d $F_{2's}$ originating the F_3 families.

Table 5. Faba bean Segregation for field resistance to rust (*Uromyces fabae* Pers, Schart) in the F_1 hybrids and ten F_2 populations.

Cross	Observed plant	IP class					Observed ratio R : S	1 Gene hypothesis	$\chi2$	P value
		0	1	2	3	4		Expected ratio R:S		
F_1^*	35	35	-	-	-	-	35 0	1: 0 (35: 00)	-	-
F_1^*	25	25	-	-	-	-	25 0	1: 0 (25: 00)	-	-
F_2	50	36	6	3	3	2	42: 8	3:1 (37.50: 12.50)	2.193	0.212
F_2 [a]	45	29	4	3	7	2	33: 12	3:1 (34.00: 11.00)	0.120	0.943
F_2 [b]	37	22	4	7	3	1	26: 11	3:1 (27.75: 9.25)	0.441	0.482
F_2	40	28	6	3	3	-	34: 6	3:1 (30.00: 10.00)	2.133	0.451
F_2	52	36	4	8	4	-	40: 12	3:1 (39.00: 13.00)	0.103	0.284
F_2 [c]	40	23	7	7	2	1	30: 10	3:1 (30.00: 10.00)	-	0.451
F_2 [d]	44	28	3	5	7	1	31: 13	3:1 (33.00: 11.00)	0.303	0.772
F_2	56	35	3	8	8	2	38: 18	3:1 (42.00: 14.00)	1.526	0.134
F_2	39	25	6	5	3	-	31: 8	3:1 (29.25: 9.75)	0.419	0.441
F_2	47	33	4	3	6	1	37: 10	3:1 (35.50: 11.50)	0.259	0.374
F_2 Total	450	295	47	52	46	10	342: 108	3:1 (338.50: 111.50)	0.146	0.961

F_1 from a resistant × susceptible cross.
a, b, c, d $F_{2's}$ originating the F_3 families.

Table 6. Faba bean Segregation for field resistance to chocolate spot (*Botrytis fabae* Sard) in 26 F_3 families from four different F_2populations

F_3 Family	F_2 phenotype	Observed plant	Observed ratio R : S	Gene hypothesis Expected ratio R : S	$\chi2$	P value
1	0	32	26 : 6	3 : 1 (24 : 8)	0.667	0.301
2	0	30	22 : 8	3 : 1 (22.50 : 7.50)	0.044	0.473
3	3	21	20 : 1	0 : 1 (0 : 21)	-	-
4	0	31	28 : 3	1 : 0 (31 : 0)	-	-
5	0	24	24 : 0	1 : 0 (20 : 0)	-	-
6	0	17	15 : 2	1 : 0 (17 : 0)	-	-
7	2	25	2 : 23	0 : 1 (0 : 25)	-	-
8	0	22	20 : 2	1 : 0 (22 : 0)	-	-
9	0	10	10 : 0	1 : 0 (10 : 0)	-	-
10	0	32	21 : 8	3 : 1 (24 : 8)	1.500	0.658
11	0	29	26 : 3	1 : 0 (29 : 0)	-	-
12	0	16	15 : 1	1 : 0 (16 : 0)	-	-
13	2	25	1 : 24	0 : 1 (0 : 25)	-	-
14	0	18	0 : 18	1 : 0 (18 : 0)	-	-
15	2	24	0 : 23	0 : 1 (0 : 24)	-	-
16	3	26	3 : 23	0 : 1 (0 : 26)	-	-
17	0	25	21: 4	1 : 0 (22 : 0)	-	-
18	4	25	0 : 25	0 : 1 (0 : 25)	-	-
19	0	30	23 : 7	3 : 1 (22.5 : 7.5)	0.044	0.042
20	0	22	16 : 6	3 : 1 (16.5 : 5.5)	0.060	0.624
21	0	24	0: 24	1 : 0 (24 : 0)	-	-
22	3	21	1 : 20	0 : 1 (0 : 21)	-	-
23	0	25	25 : 0	1 : 0 (25 : 0)	-	-
24	0	27	21 : 6	3 : 1 (20.25 : 6.75)	0.111	0.231
25	3	30	3 : 27	0 : 1 (0 : 30)	-	-
26	2	19	1 : 18	0 : 1 (0: 19)	-	-

F_3 1-5 from F_2 [a] ; F_3 6 - 13 from F_2 [b]; $F_3$14 -18 from F_2 [c]; and $F_3$19 - 26 from F_2 [d] (cf. Table 4).

Table 7. Faba bean Segregation for field resistance to rust (*Uromyces fabae* Pers, Schart) in 26 F_3 families from four different F_2 populations

F_3 Family	F_2 phenotype	Observed plant	Observed ratio R : S	Gene hypothesis Expected ratio R : S	$\chi2$	p-value
1	0	36	26: 10	3 : 1 (27 : 9)	0.145	0.230
2	0	23	22 : 1	1 : 0 (23 : 0)	-	-
3	0	33	30 : 3	1 : 0 (33 : 0)	-	-
4	2	30	2 : 28	0 : 1 (0: 28)	-	-
5	0	23	20 : 3	1 : 0 (23 : 0)	-	-
6	0	15	15 : 0	1 : 0 (15 : 0)	-	-
7	0	22	17 : 5	3 : 1 (16.5: 5.50)	0.060	0.129
8	0	18	17 : 1	1 : 0 (18 : 0)	-	-
9	2	17	1: 16	0 : 1 (0: 17)	-	-
10	0	40	5 : 35	0 : 1 (0: 40)	-	-
11	0	26	23 : 3	1 : 0 (26 : 0)	-	-
12	3	12	0 : 12	0 : 1 (0: 12)	-	-
13	4	20	16 : 4	3 : 1 (15 : 5)	0.267	0.364
14	0	19	18 : 1	1 : 0 (19 : 0)	-	-
15	0	26	21 : 5	1 : 0 (26 : 0)	-	-
16	3	23	18 : 5	3 : 1 (17.25 : 5.75)	0.131	0.369
17	0	28	3 : 25	0 : 1 (0 : 28)	-	-
18	0	20	20 : 1	1 : 0 (20 : 0)	-	-
19	0	29	3 : 26	0 : 1 (0: 29)	-	-
20	4	20	17 : 3	3 : 1 (15 : 5)	1.067	0.862
21	0	21	20 : 1	1 : 0 (21 : 0)	-	-
22	0	23	1: 22	0 : 1 (0: 30)	-	-
23	0	34	1 : 34	1 : 0 (34 : 0)	-	-
25	0	28	0 : 28	0 : 1 (0 : 28)	-	-
24	2	24	17 : 7	3 : 1 (18 : 6)	0.223	0.125
26	0	20	16 : 4	3 : 1 (15 : 5)	0.267	0.365

F_3 1-5 from F_2 [a] ; F_3 6 - 13 from F_2 [b]; $F_3$14 -18 from F_2 [c]; and $F_3$19 - 26 from F_2 [d] (cf. Table 5).

The resistance in faba bean inbred, which is reported in the previous study was confirmed by the findings of Coelho1& Monteiro, (2003) during their work on broccoli in open field against *Peronospora parasitica* Pers. ex Fr., which was contradicted to their work in greenhouse conditions (Coelho & Monteiro, 2000). The exceptions resulted from a putative resistant F_2 plant, which was obviously a false resistant as presented in Tables 4 and 5, respectively. As extension to the behavior of the resistant and susceptible progenies, the F_3 families, which resulted from the susceptible F_2 *Vicia faba* plants, were uniformly susceptible (S). This finding was confirmed through the infection by each of the chocolate spot (*B. fabae*) and rust (*U. fabae*) diseases.

Segregations of the offspring's ratios 3 R: 1 S indicates that the resistance to foliar diseases (chocolate spot and rust) is controlled by a single dominance locus. This finding is in agreements with that reported by some others authors (Dickson & Petzoldt, 1993 and Mahajan *et al*., 1995).

On the other hand, in USA, Hoser-Krause *et al*., (1987), found that the resistance to downy mildew disease is explained by a single recessive gene in a broccoli line at a four-to five-leaf stage. While Wang *et al*., (2001), noted that the resistance in a doubled-haploid line developed from‘Everest’ broccoli controlled by two complementary dominant genes from a three-to four-leaf stage, whereas, it probably represents a different types of resistance, which were expressed at an early stage of crop development.

However, there is evidence of high virulence for the fungle pathogens *B. fabae* and *U. fabae* present in the testing field at the field Experimental Farm of the Fac. of Agric., Suez Canal Univ., Ismailia, Egypt. There is no doubt that *Vicia faba* accession, which have a resistant degree at seedling stage to some isolates of the fungal pathogens collected from Ismailia area, may be were susceptible to the same pathogens collected from other sites. While, it contrast the accession of *Vicia faba* may be susceptible to isolates of *B. fabae* or U. fabea under Ismailia conditions, it can be resistant to the same isolates of pathogen through other conditions in other sites. In this respect, Coelho & Monteiro (2000), found that *Brassica oleracea* accessions resistant at cotyledon stage to various French isolates were susceptible to a Portuguese isolate collected at Batalha. Also, Tronchuda cabbage ‘Murciana’ is resistant to isolate P005 from the UK and susceptible to isolate P523 collected at Batalha at cotyledon and adult-plant stages.

The finding that the resistant trait is controlled by single dominant gene is a good promising mean for its direct use in faba bean breeding or for transfer to other bean crops. More studies is recommended for establishing a line that is resistant for wide range of diseases.

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