

Genetic Resource of the Resistance of *Vicia faba* L. against the Black Bean Aphid, *Aphis fabae* Scopoli

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Abstract

The Black bean aphid *Aphis fabae* Scopoli (Homoptera: Aphididae) is a serious pest of faba bean, *Vicia faba* L. (Fabaceae) in Algeria. The use of resistant cultivars may reduce the impact of this pest on broad bean production and at the same time reduce environmental risks and control costs. The level of resistance of fourteen cultivars of broad bean, *Vicia faba* was screened in the field against the main aphid pest of faba bean, the Black bean aphid, *Aphis fabae* Scopoli during January to April 2011 in Biskra region (in the east of Algeria). Among the cultivars tested, six cultivars (1, 9, 12, 13, 14 and 15) were the most resistant in the three counts, while three cultivars (4, 6 and 11) were showed a high susceptibility against this aphid at least once. The remainder of cultivars (3, 5, 7, 8 and 10) revealed an unsettled level of resistance. The relationship between the level of resistance and morphological characters of cultivars indicated that the resistant cultivars have a longer leaflet than the high susceptible cultivars. In the other hand, the statistical analysis showed that no significant differences on the plant height and the leaflet width in the tow category of cultivars (resistant and high susceptible).

Keywords: *Aphis fabae*, cultivars, morphological character, resistance, *Vicia faba*.

1. Introduction

The broad bean, *Vicia faba* L. (Fabales: Fabaceae) is the most important food legume crop in Algeria with 42 386 tons of dry matter (FAO stat, 2013). In Algeria, broad bean production

includes highly diversified local cultivars. About 68 locally cultivars, have been identified by morphological and agronomic characterization (Meradsi, 2009).

Among the insects subservient to the bean aphids, occupy a very special place. On the plane damage, aphids are considered today among the most important insect pests inducing significant economic losses. They cause damage to both types. Direct damage correspond to multitudes of food taken, leading to a weakening of the plant, the abortion of flowers, rolling and falling leaves reducing photosynthetic area and drying of shoots (Delorme, 1997). Indirect ravages involved on the one hand by the affine system of fungus *Fumago* spp., designated by the concept sooty mold on the layer of honeydew expelled by aphids and secondly by the transmission of plant viruses.

The black bean aphid, *Aphis fabae* Scopoli (Homoptera: Aphididae) is the most destructive insect pest of broad bean, in Algeria. This aphid colonises a broad range of Fabaceae species (Bond and Lowe 1975; Cammell 1981; Cammell et al., 1989). Damage caused by the black bean aphid is of a notably indirect nature; by the transmission of viral diseases, such as the *Broad bean wilt fabavirus* (BBWV) and the *Faba bean necrotic yellows nanovirus* (FBNYV) (Franz et al., 1999). *A. fabae* is usually controlled using insecticides. However, the high costs of synthetic pesticides and associated toxicity risks (Mihale et al., 2009), the increasing development of insect resistance to pesticides, (Ogendo et al., 2003), the destruction of beneficial insects (pollinators, parasitoids and predators), pesticide residue magnification in humans and wildlife and disruption of ecosystem (Ruchika and Kumar, 2012), have increased the need to search for alternative insect control methods.

Plant resistance may be the most effective, economical, and environmentally sound management tactic to control *A. fabae* in crops. Recently, some progress has been archived in screening broad bean cultivars against black bean aphid and a number of cultivars have been identified as possible source of resistance for breeding programs (Khelfa, 2004; Meradsi, 2009).

The aim of this study was to evaluate the resistance of 14 locally cultivars of broad bean against the most pest of bean witch as the black bean aphid, *A. fabae*. A complementary objective was to research a possible relation between the level of resistance and morphological aspect of the cultivars.

2. Materials and methods

2.1 Study area

The two experiments were done at the Scientific and Technical Research Center for Arid Areas in Biskra (Algeria).

2.2 Plant

The plant material used in the first experiment conducted in field is composed of 14 broad bean cultivars, *Vicia faba* L. (Fabales: Fabaceae) collected from two locations situated in the east of Algeria: Biskra (9 cultivars) and Batna (5 cultivars) (Table 1).

Table 1. Origin and code of cultivars tested

Origin	Biskra	Batna
Code of cultivars	1, 3, 5, 7, 8, 12, 13, 14 and 15	4, 6, 9, 10 and 11

2.3 Insect

The aphids used in the first experiment were obtained from a single apterous adult of *Aphis fabae*. They were collected in early February, 2011 from broad bean plants in a field situated at the region of Biskra. The aphids were reared on broad bean seedlings (*V. faba*) under greenhouse conditions of 21 ± 2 °C, $60 \pm 5\%$ RH and 14: 10 (L: D) h photoperiod.

2.4 Evaluation of the resistance in the field

In the first experiment, the planting bean seeds representing 14 bean cultivars were produced at a rate of 12 seeds per cultivar. The depth seedling was 5 cm. The spacing is 100 cm between rows and 90 cm between plants. The culture is conducted without insecticide treatment and without fertilization. According to El-Dafrawi et al. (1991), one apterous adult was placed on each plant at 13 growth stage (three leaves unfolded) (Mier, 2001). Counts of individuals within colonies formed on each plant are made 10, 20 and 30 days after infestation, firstly to see the best cultivars that resist *A. fabae* and also the persistence of this resistance with time (Meradsi, 2009; Lebbal, 2010).

The level of resistance of all cultivars adopted in this experiment was proposed by El-Dafrawi et al. (1991). The numbers of adults and nymphs were counted and assigned to four categories:

Grade 1: ≤ 5 aphids; resistant cultivar

Grade 2: 6-20 aphids; tolerant cultivar

Grade 3: 21-50 aphids; susceptible cultivar

Grade 4: > 50 aphids; highly susceptible cultivar

2.5 Relationship between level of resistance and morphological aspect of cultivars

In objective to make a relationship between the morphology of cultivars and their level of resistance, a second experiment was achieved for the description of some organs of plants. The measures were carried out on the stems (the height of plant), foliage plants resistant cultivars (1 and 12) and highly susceptible cultivars (4 and 11) (the length and the width of the leaflet) according to the standards proposed by the UPOV (2003). The planting of 04 cultivars bean seeds was achieved due to 10 seeds per cultivar. The spacing is 100 cm between rows and 35 cm between plants.

Note: the code 3 that correspond the plant height, the code 9 that correspond the leaflet length and the code 10 correspond the leaflet width; these codes were proposed by the International Union for the Protection of new Varieties of Plants (UPOV, 2003).

2.6 Statistical analysis

The data concerning the height plant (3), the leaflet length (basal pair of leaflet at secondary node) (9) and the leaflet width (basal pair of leaflet at secondary node) (10) were compared between resistant and highly susceptible cultivars using one-way analysis of variance (ANOVA) at $P \leq 0.05$ (Gomez and Gomez, 1984). All statistical analyses were performed with SPSS statistical software (Version 10.0.5) (SPSS, 1999). The two experiments were designed in a randomized complete block design (RCBD).

3. Results

3.1 Resistance in the field

In the first count, 09 cultivars were classified as resistant. At the time in the second count, only 08 cultivars are resistant and 2 highly susceptible cultivars. Lasting the third count, 09 cultivars are classified resistant and only one highly susceptible cultivar (Table 2).

Table 2. Distribution of cultivars during the three counts (10, 20 and 30 days after infestation).

Counts	Level of the resistance			
	Resistant cultivars (≤ 5 aphids)	Tolerant cultivars (6-20 aphids)	Susceptible cultivars (21-50 aphids)	Highly susceptible cultivars (> 50 aphids)
The first	1, 5, 7, 8, 9, 12, 13, 14 and 15	3, 4, 6, 10 and 11	-	-
The second	1, 5, 9, 10, 12, 13, 14 and 15	4 and 7	3 and 8	6 and 11
The third	1, 3, 6, 9, 10, 12, 13, 14 and 15	7 and 11	5 and 8	4

3.2 Relationship between the level of resistance and morphological character of cultivars

The table 3 indicated all the results concerning the measures on the stems and foliage of resistant (1 and 12) and highly susceptible (4 and 11) cultivars.

Table 3. Morphological characters of resistant and highly susceptible cultivars.

Legend:

3: The height of plant (cm), 9: the length of the leaflet (cm), 10: the width of the leaflet (cm).

Plants	Cultivars											
	1			4			11			12		
	Morphological characters											
	3	9	10	3	9	10	3	9	10	3	9	10
1	18.5	05.5	03.9	09.9	04.5	03.6	09.7	05.5	03.7	04.4	04.4	02.5
2	14	04.6	03.5	11.6	04	02.2	11.3	04.4	03.2	11.1	04.9	02.3
3	14.7	05.2	02.6	13.1	04.1	03.3	07.4	03.9	02.6	06.1	03.4	01.6
4	13.1	05.8	03.3	15.3	04.5	03.5	10.2	05.3	02.8	10.3	03.5	01.9
5	12.4	05.3	02.4	11.5	04.7	03.2	11.3	03.6	02.7	14.1	04.7	02.6

6	13.7	05.6	03.7	08	03.6	02.4	11.3	04	02.9	08.9	03.8	02.3
7	12.1	05.7	02.7	11.3	04	02.4	09.4	04	02.6	06.3	03.6	02.6
8	15.3	05.9	03.4	07.6	03.9	02.8	10.4	04.3	02.8	11.4	03.3	02.5
9	13	05.3	02.6	07.8	03	02.3	09.7	04.8	03.3	10.3	05.1	02.4
10	11	05.8	03	09	03.5	01.6	09.8	04	01.9	07.3	03.4	01.7

Statistical analysis showed no significant difference ($P > 0.05$) between the resistant and highly susceptible cultivars for the tow characters: the plant height (3) and the leaflet width (10). In contrast, the results indicated a significant difference among the resistant and highly susceptible cultivars for the character of the leaflet length (9) ($F_{4,10} = 5.15$; $P = 0.029$). The resistant cultivars have a longer leaflet than the highly susceptible cultivars (Table 4).

Table 4. Relationship between level of the resistance and morphologic of resistant and highly susceptible cultivars.

n: number of replications, ns: not significant. Values followed by different letters within a column are significantly different (ANOVA: * $P < 0.05$).

Morphological character	Level of resistance	Means \pm SE	n	$F_{4,10}$	P
The plant height; 3 (cm)	Resistant cultivars	10.40 \pm 0.78a	20	1.576	0.217 (ns)
	Highly susceptible cultivars	10.28 \pm 0.43a			
The leaflet length; 9 (cm)	Resistant cultivars	4.74 \pm 0.21a	20	5.154	0.029*
	Highly susceptible cultivars	4.18 \pm 0.13b			
The leaflet width; 10 (cm)	Resistant cultivars	2.67 \pm 0.14a	20	0.372	0.546 (ns)
	Highly susceptible cultivars	2.79 \pm 0.13a			

4. Discussion

The results obtained during the three counts allowed to classify broad bean cultivars studied according to their level of resistance to *A. fabae*. Among the cultivars tested, six cultivars (1, 9, 12, 13, 14 and 15) were the most resistant in the three counts, while three cultivars (4, 6 and 11) were showed a high susceptibility against this aphid at least once. Similar work is carried out by several authors. In 2009, Meradsi, found 19 resistant cultivars among 68 cultivars of *V. faba* tested against *A. fabae*. Lebbal (2010), during work on the resistance of broad bean against alfalfa aphid has selected 16 resistant cultivars among 62 cultivars tested. . In other work, Khelfa (2004) was selected 6 resistant cultivars against *A. craccivora* among 48 cultivars collected in the Biskra region. In Egypt, after 4 years of study on resistance of 7156 bean cultivars against *A. craccivora*, El-Defrawi et al. (1991) were able to select 114 resistant cultivars.

On these resistant cultivars, installed aphids are difficult to meet their basic needs. For this reason, they produce fewer individuals compared to those reared on susceptible cultivars. Indeed, Kordan et al. (2008) demonstrated that the fertility of the pea aphid, *Acyrtosiphon pisum* on lupine resistant plants was between 0.1 and 0.4 larvae, while it was 17.4 individuals on a susceptible cultivar. In other study, Ma et al. (2006) found that females of the aphid *Sitobion avenae* produced less than 300 larvae in 100 ears of the resistant cultivar "KOK 1679» against 1400 individuals on the susceptible cultivar 'Lovrin 10'.

The results achieved in the field only a partial estimate of the resistance. Aphid colonies

counted on the plants do not actually correspond to those issued by the females used in artificial infestation. Other parameters such as edge effects, the age of the plant, the attractivity of the cultivar, seed quality and installation of auxiliary insects can participate in the increase or decrease of insects.

Since the plants are not covered, individuals initially used in artificial infestation of plants or their progeny can settle freely on the most attractive cultivars to participate in an additional infestation. Possible natural contamination can also occur.

In the field, the setting chosen for the evaluation of cultivar resistance and is based on the importance of aphid colonies express much resistance by antibiotic mechanisms and antixenotic not plant tolerance.

Resistance bean cultivars can be attributed to morphological and biochemical factors. Among the morphological factors, there are especially the thickness and structure of the wax layer covering the plant. The color and size of the foliage are other morphological parameters that can also be involved in this resistance. Indeed, the results presented in the table 6 showed that resistant cultivars are characterized by long leaflets compared to highly susceptible cultivars. In contrast, Meradsi (2009) found that the highly susceptible cultivars bean have a narrow leaflets than the resistant cultivars. Lebbal (2010) mentioned that the bean resistant cultivars or highly susceptible have the same morphological characters. Similarly, Tolmay et al. (1999) noted that the susceptible cultivars are those with narrow leaves in wheat.

The quality of food offered by the host plant to its biological pests is another parameter that determines their development, growth and reproduction. For example, the amino acid composition of the superficial plant tissues can determine the nutritional behavior of aphids. Cisneros and Godfrey (2001) found that there is a positive correlation between the abundance of *Aphis gossypii* on cotton plants and the content of the nitrogen in plants. Mustapha and Samara (1999) reported on their part that the variety of the bean supported infestation by *A. fabae* is the plant that contains the lowest level of nitrogen and phosphor rate on higher. Probably, the bean resistant cultivars to *A. fabae* those are poor in nitrogen and sugars and more or less rich in phosphor.

5. Conclusion

In light of the results obtained, it is observed that among the 14 cultivars tested in this study, 12 are classified as resistant to *A. fabae* at least once. While 6 cultivars (1, 9, 12, 13, 14 and 15) have retained this level of resistance in the three counts made. In contrast, 03 cultivars (4, 6 and 11) are considered highly susceptibles at least once. The resistant cultivars have long leaflets than the highly susceptible cultivars. It would be interesting also to identify the quality and quantity of volatiles repulsive resistant cultivars by the coupling of gas chromatography and mass spectrometry. The Determining of the thickness and the chemical composition of the wax of resistant cultivars that covers its leaves can also contribute to the explanation of its resistance level.

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