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Original Research Article

Interrelationships Among Some Aphids and their Host Plants

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In Egypt and other countries, broad bean, wheat and corn are by far among the most important crop plants, for both local consumption and export. Field experiments were designed to evaluate susceptibility and or resistance of 8,8and 15 genotypes of faba bean, wheat and corn, respectively. A total of 14 aphid species representing 11 genera belonging to two subfamilies (Aphidinae and Fordinae) and following two families (Aphididae and Pamphigidae). Seven aphid species of wheat and maize, 6 aphid species from faba bean were recovered. First view, of interrelationships among aphids and their host plants in our opinion is the direct and indirect damages done to these plants due to feeding by those aphid species. Concerning the indirect damage that some aphid species transmitted to virus diseases. By studying the infestation degrees of the population dynamics of aphid species on shoots, leaves, stalks and on whole plants, in the present studies the different plant species can be grouped into susceptible and moderately susceptible or resistance. Comparison between six chemical compounds and dry weight and moisture percentage of susceptible and resistant variety of each plant species were studied and discussed.

Keywords Aphids, host plants, faba bean, maize, wheat, ecological studies.

INTRODUCTION

Aphids are considered among the most serious insect pests of different plants in Egypt as well as all over the world. In addition, some species are vectors of certain virus diseases. On the other hand, wheat, *Triticum aestivum* L. ; corn *Zea mays* L. ; broad bean *Vicia faba* L. Are by far among the most important crop plants in Egypt, for both local consumption and export. These crops are liable to infestation by some aphid species (Hammad 1997).

Biological and ecological studies on aphid species assured that aphids have several overlapping pathenogenetic generations. Intraspecific genetic variation and contemporary evaluation can be important factors shaping the ecology of species interactions (Whitham et al. 2003; Fussmann et al. 2007; Thompson 2013). Host plant resistance responses contain many physiologic processes that will actively express plant pathogen-related genes to defend plants from pest damage. Some chemical compounds are commonly produced in these processes, such as ethylene (Moran et al. 2002).

Ethylene is a gaseous compound that is recognized as an important pathogen defense mediator in plant pathogen interactions. (Muller, 1976) mentioned that many phytophagous insect species were split off into biotypes or bionomical races distinguished only by their host plant selection. Even in the case of authorized subspecies the food plants may concern the most outstanding feature. Practical aspects usually relate to the fact that host races may be of very different economic importance as pests or as virus vectors, though their existence renders the breeding of resistant cultivars more difficult. As to the theoretical aspects the study of host races served for analysis of the mechanisms of host acceptability and host avoidance. Aphidoidea exhibits many examples of species or form complexes being composed of taxa differing by their host plants.

MATERIALS AND METHODS

Experimental design

(1): Studies on the faba bean aphids.

At the start of the experiment on the 2nd week of Nov. 2012 and 2013 the treatments (faba bean cultivars) were arranged in a Randomized complete Block Design with three replicates. Each plot was 2x2 m long and consisted of 4 rows and 50 cm apart. The distance between each two hills was 20 cm, and each hill was planted with two seeds. After ten days from sowing the plants were thinned up to one plant per a hill, and each plot included 80 plants. The normal agricultural practices were followed and no pesticide treatments were applied throughout the experiment.

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Ecological studies

Sampling took place as soon as the plants appeared above ground, about 3-4 weeks from sowing. Weekly samples of ten shoots were taken at random from the susceptible genotype-Giza 4 to survey aphid species and their natural enemies. On the other hand, three shoots were randomly picked out, fortnightly until harvesting, from each plot or genotype to study the population density of the common abundant aphid species. Infested shoots by the aphids of each plot were kept in polyethylene bags and transported immediately in the same day to be examined in the laboratory.

The sampled shoots were carefully investigated and all aphids and instars were collected and placed in small glass tubes containing 70% ethyl alcohol. The aphid numbers are counted and determined under stereoscopic binocular microscope as apterae and altae viviparae adult females as well as all immature stages (alatoid nymphs and larval). The eight faba bean genotypes were evaluated against natural infestation of aphid species under natural field conditions. The fundamental measure is as follows:

1- % of infestation /plot on each cultivar.
2- Population densities of aphid species.
3- Symptoms of aphid injury /cultivar, (Sing and Bakhetia 1987).

(2) Studies on the wheat aphids

Eight wheat (*Triticum aestivum* L.) genotypes (Table 1) were selected for these studies. Field experiments were carried out during three successive seasons of wheat plantation 2011-2012; 2012-2013 and 2013-2014.

Experimental design

At the start of the experiment on the 2nd week of Nov. 2011-2012 and 2013 the treatments (eight wheat genotypes) were arranged in a Randomized complete block design with three replicates. Each plot 2x2 m long, 10 rows, and 20 cm apart. After 10 days from sowing the plants were thinned up to one plant per a hill.

Ecological studies

Sampling took place as soon as the plants appeared above ground (3-4 weeks). Samples of ten tillers were randomly taken at weekly intervals from only genotype Giza 163 (susceptible one) to survey aphid species. Tillers infested by aphids of each plot were kept in polyethylene bags and then examined in the laboratory. The same methods as in faba bean treatment were used for wheat treatment (criteria for resistance).

(3) Studies on the maize aphids

Fifteen maize (*Zea mays* L.) genotypes (Table 1) were selected for these studies.
At the start of experiments on the 2nd week of June 2012 and 2013 the genotypes (8 single cross white , two single cross yellow, two tri-cross white, two lines and Baladi (Table 1) were arranged in Randomized complete Block Design with three replicates. Each plot was 3x3 m long and consisted of 5 rows and 60 cm apart. The other steps applied as in wheat studies.

Ecological studies

Samples took place as soon as the plants appeared above ground, about 3-4 week from sowing , when the plants of all genotypes were about 15 cm height. Samples of six plants were randomly taken at biweekly intervals from only genotype Baladi (susceptible one) to survey aphid species. On the other hand, two plants were picked out randomly, at two weekly intervals and continued until harvesting. The infested plants were kept in polyethylene bags and examined in the laboratory. The other processes applied as in the other two mentioned plants.

Laboratory studies

Chemical composition of host plants

1. The effect of free amino acids and ammonia were determined mg/100 g dry weight matter using the method of Hamilton 1962.
2. The effect of phenol compounds on aphid infestation. Phenol compounds were determined as tannic acid mg/100 g dry weight matter using the method of Ranganna 1977.
3. The effect of reduced: non reduced sugar; total carbohydrate and moisture content on aphid infestation were determined according to Nelson 1944; Plummer 1971 and Dubois et al 1956.

RESULTS AND DISCUSSION

The degrees of infestations were calculated as the total numbers of alatae and apterae viviparous adult females on some aphid species per plant sample. Low infestation (5%, moderate, 5-10% and more than 10% /plant). A total of 14 aphid species represented 11 genera belonging to two subfamilies (Aphidinae, 13 species and Fordinae, one species) and following two families (Aphididae and Pemphigidae respectively of superfamily Aphidoidae were collected and identified. On the other hand, the present study indicated that a maximum number of 7 aphid species were recovered from wheat and maize genotypes.

More than 2000 individuals, including morphs (apterae,alatae viviparous, adult females and a certain number of alata male), larval and alatoid nymphal instars of these 14 aphid species under consideration were mounted and identified. First view of the interrelationships among aphids and their host plants in our opinion, the direct and indirect damages done to these plants due to feeding by these aphid species. As generally known, most aphids feed on the sieve tube sap, which consists of an aqueous solution of sucrose and other substances.

On faba bean plants

Data in Table (3) revealed that faba bean plants were infested by six aphid species, in which the cowpea aphid, *A.craccivora* was the most dominate species. Infestation by alate females of the cowpea aphid began after one month of plantation on broad bean plants after forming their flower buds. The feeding of aphids caused leaves curling; rosette the plant foliages associated with dwarfs the plants.

Table 1: A list of plant species and genotypes used in the experiments to evaluate susceptibility to aphid species infestations

S	Cultivar genotypes		
	Faba bean Vicia faba L.	Wheat Triticum aestivum L.	Maize (Corn) Zea mays L
1	Giza 1	Giza 150	S.c. 10
2	Giza 2	Giza 163	S.c. 120
3	Giza 3	Giza 164	S.c.122
4	Giza 4	Giza 165	S.c.124
5	Giza 22	Giza 167	S.c.125
6	Giza 429	Sakha 69	S.c.126
7	Giza 964	Sids 1	S.c.128
8	Line 69/531/21	Sids 2	S.c.129
9	-	-	S.c.151
10	-	-	S.c.152
11	-	-	T.w.c. 310
12	-	-	T.w.c. 320
13	-	-	L.35
14	-	-	L.65
15	-	-	Baladi

S.c. 10, 120, 122, 124, 125, 126, 128, 129 = Single cross white, S.c. 151, 152 = Single cross yellow, T.w.c. 310, 320 Triple cross and L. 35, 65 = Line.

Table 2: Records of Temperature (°C), Relative Humidity (% R.H.) obtained from the Meteorological Station in Menoufia during three successive seasons from2012 to 2014

Month	2012				2013				2014			
	Temperature °C		R.H.%		Temperature °C		R.H.%		Temperature °C		R.H.%	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	18.3	7.1	91.2	48.4	19.2	6.4	90.7	55.3	19.1	7.2	92.0	47.0
February	19.2	8.1	95.4	41.3	19.4	6.3	93.1	41.2	20.1	7.7	91.6	44.5
March	21.5	8.3	90.7	39.0	20.1	7.0	94.0	42.0	21.2	7.4	91.8	39.1
April	23.0	10.2	95.0	32.4	24.0	9.7	94.0	37.0	29.0	11.5	91.7	31.3
May	30.7	15.3	92.4	25.1	31.9	13.7	91.0	24.0	30.6	16.3	86.0	30.7
June	35.9	22.3	953	35.7	33.8	16.8	93.7	29.3	33.5	19.6	90.0	33.3
July	36.2	23.2	93.2	38.7	34.1	19.6	92.0	40.7	34.3	20.9	84.6	37.8
August	32.4	19.9	91.5	43.0	32.2	19.3	91.0	46.0	35.1	22.1	79.2	42.4
September	30.1	18.5	93.7	41.1	31.1	17.4	92.0	40.0	34.2	19.6	79.0	30.0
October	38.5	17.4	94.2	40.4	29.5	15.6	93.0	39.0	30.9	16.8	78.3	29.7
November	24.9	14.7	92.9	42.3	25.0	12.5	91.0	43.0	25.2	13.6	78.2	36.3
December	21.1	11.6	92.4	48.2	20.8	10.6	91.3	49.0	20.6	10.2	76.3	36.0

* Max. = Maximum and Min. = Minimum.

Table 3: Aphid species, their English name and their distributions on various host plants during 2012 – 2014

Aphid species and English name		Degree of infestation on host plant samples		
Scientific name @	English name	Faba bean	Wheat	Maize
Ac. pisum (Harris)	Pea aphid	**	-	-
Ac. gossypiiMordvilko	Unknown	*	-	-
A. craccivora Koch	Cowpea aphid	***	-	-
A. gossypii Glover	Cotton aphid	*	-	*
B. brassicae (Linnaeus)	Cabbage aphid	-	-	-
Gl. howardii (Wilson)	Unknown	-	*	-
L,erysimi(Kaltenbach).	Turnip aphid	-	-	-
Me. dirhodum (Walker)	Rose – grain aphid	-	**	-
M. persicae (Sulzer)	Green Peach aphid	*	-	*
Rh. maidis (Fitch)	Corn leaf aphid	-	*	***
lih. padi (Linnaeus)	Bird cherry oat aphid	-	***	***
Sc. graminum (Rondani)	Green bug	-	***	*
Si. avenae (Fabricius)	Grain aphid	-	***	*
Sm. betae Westwood	Bean root aphid	**	*	*

@ = G/abromyzus howardii (Wilson) and Metopolophium dirhodum (Walker)
are recorded during the present investigations for the first time in Egypt.
(-)= No infestation, (*) = Low infestation,(**) = Moderate infestation and (* * *) =High infestation.

Table 4: Analysis of variance for a population density of aphids infesting eight faba bean genotypes, December 2012 & April 2013

Source of variance	DF	MS @
Replication (R)	2	2753.1 ns
Date (D)	9	9283430.4 **
Error (a)	18	1136.9
Genotypes (G)	7	216907.2 **
D x G	63	50394.3 **
Error (b)	140	1721.8
Total	239	

Split Plot Design), Cv (a) = 6.5% and cv (b) = 8.0%, ** = Significant at 1% level and ns = Not significant, @ DF = Degree of freedom and MS = Mean square

Table 5: Comparison among susceptibility of eight genotypes of faba bean to infestation by aphid species under field conditions in Menoufia, at two weekly intervals during December 2013 – April 2014

Date of collection	Population densities of aphid species on eight faba bean genotypes								Population mean
	Giza 1	Giza 2	Giza 3	Giza 4	Giza 22	Giza 429	Giza 964	Line 69/531/21	
8/12/96	25.0 g	26.0 g	14.7 g	26.3 gh	27.0 fg	17.7 f	14.0 g	14.0 f	20.6 gh
22/12/96	342.3 d	360.7 d	177.3 e	377.3 d	396.7 c	2883 d	285.7 de	258.0 d	310.8 d
5/1/97	1245.3 b	1264.7 b	611.7 c	1275.0 b	1294.0 b	961.0 c	951.0 c	870.0 e	1059.1 c
19/1/97	2056.3 a	2056.0 a	1191.7. a	2122.3 a	2154.0 a	1791.7 a	1763.3 a	1609.7 a	1843.1 a
2/2/97	1047.7 c	1069.0 c	801.0 b	1075.7 c	1334.3 b	12503 b	1375.0 b	13573 b	1163.8 b
16/2/97	217.3 e	212.7 e	205.0 e	289.7 e	322.3 d	281.7 d	254.0 e	240.7 d	252.9 e
2/3/97	388.0 d	395.7 d	291.3 d	401.3 d	455.3 c	316.0 d	325.0 d	279.7 d	356.5 d
16/3/97	94.0 f	103.3 f	98.0 f	211.0 f	194.3 e	1643 e	152.0 f	116.0 c	141.6 f
30/3/97	25.7 e	33.7 g	24.3 g	81.0 g	75.3 f	66.3 f	44.3 g	50.7 ef	50.2 g
13/4/97	0.0g	0.0 E	0.0 g	0.0 h	0.0g	0.0 f	0.0 g	0.0 f	0.0 h
Genotype mean	544.2	552.2	341.5	586.0	625.3	513.7	516.4	479.6	519.9

Samples passed on three replicates and each replicate was three faba bean shoots. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Infestations by other recorded species (*Ac.pisum; Ac.gossypii;Sm.betae*) caused a great damage and had other symptoms to the host plant.

On wheat plants

As shown in Table (3), there were 7 aphid species attacked wheat genotypes. However, infestations of the bird cherry oat aphid (*Rh.padi*) , the greenbug (*Sc.graminum*) and the grain aphid (*Si.avenae*) were dominants in their distributions during wheat plantation season. The bird cherry oat aphid, the grain aphid and the rose-grains aphid prefer to feed on the oldest leaves and on subterranean stems of wheat plants, while the corn leaf aphid and the green bug prefer to feed on the youngest leaves and foliage of wheat plants.

On maize plants

Data in Table (3) indicated that maize plants were infested by 7 aphid species. The corn leaf aphid, *Rh.maidis* and the bird cherry oat the honeydew of them and cause characteristic deformations.

Resistance of different hosts to aphid infestations

Statistical analysis of data given in Table (4) showed that the interactions within the periods the faba been genotypes have highly significant differences on the population densities of aphids. Data present in Table (6; 7) indicated that the population, densities of aphid species reached their maximum numbers overall faba bean genotypes just after six weeks of infestation, this indicate a considerable variation among the susceptibility of the eight genotypes of faba been concerning the resistance of wheat to aphids, as a total, the % of population densities were 57.7%; 22.3%; 12.4% and 6.4% due to the attack of different aphid species *Sc.graminum* rond; *Si.avenae* Fabr; *Rh.padi* L. and *Me.dirhodum* Walker respectively.

Data obtained that no wheat genotype has resistance or even tolerance against aphid infestation. For maize aphid infestation, data in Table (3) and (16) revealed that these were seven aphid species attacked maize plants, between them, *Rh.maidis* Fitch and *Rh.padi* L. Were the most dominant species were recorded the % of population densities, 51.7% and 34.6% respectively.

SUMMARY AND DISCUSSION

Comparison between six chemical compounds and dry weight and moisture percentage of susceptible and

resistant variety of each plant species were studied and discussed. The susceptible faba been genotype (Giza 22) to infestation by cowpea aphid and pea aphid together has high concentration in mg/100 g dry matter of phenolic compounds and total carbohydrates as well as a high percentage of moisture, while semi resistant of faba bean genotype (Giza 3) has a high concentration of each free amino acid compounds, ammonia, reducing sugar and non-reducing sugar as well as dry weight in g/100g fresh weight of plant sample.

For maize plants, this is no evidence as yet as to whether the total concentration of certain free amino acids controlling the susceptibility or resistance to aphid infestation. These are remarkable variations between the concentrations of six chemical compounds as well as moisture percentages in resistant and susceptible genotypes of the same host plant, and among the three different host plant kinds.

1- There is a positive correlation between the concentration of free amino acids in host plant saps and the resistance level of those plants.
2- The tendency of the concentration of phenolic compounds was completely in the inverse trends to ammonia contents.
3- Increase in the percent of moisture and decrease in the concentration of free amino acids enhanced the susceptibility of host plants to aphids infestation and distribution.

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