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## Effect of Different Host Plants on Some Biological and Physiological Parameters of Cowpea Aphid, *Aphis craccivora* Koch Under Certain Laboratory Conditions

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### ABSTRACT

The medicinal and aromatic plants are considered one of the most important untraditional agricultural commodities which can be used as a base for Egyptian markets. Therefore, the present studies were carried out on 5 medicinal and aromatic crops at Assiut Governorate during two consecutive growing seasons of 2011-2013 at Shotb district and Abnoub district. Various biological parameters of *Aphis craccivora* Koch were studied on coriander and henna host plants, in addition to bean, as a primer host. Other host plants showed high mortality rates for aphids when it was reared on. As for the survival percentage of *A. craccivora* on the three cultivars, the highest percentage was recorded on henna plants, followed by coriander and bean plants. *A. craccivora* adult's longevity extended when reared on henna host plants, adults who reared on coriander had the highest number of offspring, followed by henna then bean host plants. The survival rates of total nymphal stages were the highest when reared on the henna host plant, while the lowest was recorded on the bean. Different host plants in the 2nd generation seemed to be less effective on the pest's life table parameters. Superoxide dismutase activity (SOD) activity, Catalase (CAT) activity, Protein, lipids and carbohydrates content were significantly affected by different host plants. As for the digestive enzymes, the activities of  $\alpha$ -amylase and lipase enzymes were not affected with different host plants.

### INTRODUCTION

Due to medicinal and aromatic plants' relevance in medicine, particularly as a primary source for numerous pharmaceutical products, they have received a lot of attention in recent years. In addition to their usage as pesticides, medicinal herbs are utilized as natural taste and scent additions in the food industry (Abou-Zaid, 1988). Coriander (*Coriandrum sativum* L.), one of these plants, is regarded as a significant spice crop that plays a key role in flavoring ingredients and is employed in the treatment of a variety of illnesses (Sahib *et al.*, 2012; Fahmy *et al.*, 2014). Additionally, cumin (*Cuminum cyminum* L.) is a crucial component of Egypt's exports of medicines (Hassan *et al.*, 2013). Due to the helpful metabolites, they contain, they are frequently utilized as spices, vegetables, or medications (Olle and Bender, 2010).

Additionally, marjoram (*Origanum majorana L.*) is mostly utilized in fragrance and food goods (Pimple *et al.*, 2012). It is medicinally beneficial due to its stimulant and antispasmodic characteristics, and it is used to treat a variety of digestive and respiratory ailments (Chevallier, 1996). Dill seeds (*Anethum graveolens L.*) are employed as a diuretic, stomachic, and carminative (Jana and Shekhawat, 2010). Researchers have discovered that the *Lawsonia inermis L.* plant's leaves, flowers, seeds, stem bark, and roots contain anti-inflammatory, anti-tumor, anti-diabetic, hepatoprotective, and wound-healing effects (Hema *et al.*, 2010).

Because they have coexisted for millions of years, plants and insects have developed ways to get beyond each other's protection mechanisms (War *et al.*, 2012). Different biochemical and physical defense mechanisms used by plants to protect themselves include those that can poison or discourage insects (War *et al.*, 2011a, b). Aphids are major organisms that significantly reduce a plant's phloem sap production and result in the growth of fungus on the leaves (Selvaraj and Kaushik, 2014). In addition, it is thought to be a disease-carrying plant virus vector (Özder, and Sağlam, 2013). Numerous types of aphids can feed on various hosts of plants (Vorburger *et al.*, 2008). Understanding how host plants affect an insect pest's life table is crucial for population dynamics studies and pest management techniques (Ramalho, *et al.*, 2015). Parthenogenesis apterous adult female Aphids are successively created under favorable conditions, such as; abundant good quality food and a favourable climate (Ofuya, 1997).

High Reactive oxygen species (ROS) concentrations produce oxidative stress, which hinders the absorption of nutrients consumed and can harm the midgut cells of aphids (Bi and Felton, 1995). It also helps determine the performance of herbivorous insects on plants (Abdelsalam *et al.*, 2016). Superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), dehydroascorbate reductase (DHAR), se-independent glutathione peroxidase (GSTPX), glutathione reductase (GR), and low-molecular-weight antioxidants like glutathione (GSH) and ascorbic acid (ASA) are antioxidant defence mechanisms that insects can use to protect themselves (Afiyanti and Chen, 2014 Abdelsalam *et al.*, 2016).

However, one of the key components of pest control became the study of digestive enzymes and diverse food sources (Deng *et al.*, 2013). These enzymes are crucial for the fundamental physiological processes of reproduction, development, protection from pathogens and oxidative stress, and pheromone signaling (Horne *et al.*, 2009 and Kaur and Gupta, 2015).

Also, the host plants could affect nutritional requirements (Ahsaei *et al.*, 2013) and Food consumption is necessary for the insect to store protein, Carbohydrates and lipids that are more frequently utilized to maintain energy for muscular activity, morphogenesis and reproduction (Chapman, 1998). Therefore, the present study aimed to investigate the effect of medicinal and aromatic plants on cowpea aphid biology and the effect of different host plants on insect physiology and causing death.

## MATERIALS AND METHODS

Five medicinal and aromatic crops were selected (Table 1).

**Table 1:** Selected medicinal and aromatic plants for the study and their information.

Crop	Location	Scientific name	Family	Sampling period	Status
Coriander	Shotb	<i>Coriandrum sativum</i> L.	Apiaceae	Jan., 26-Apr., 5*	Seasonal
	Abnoub			Jan., 10- Apr., 6**	
Cumin		Abnoub		<i>Cuminum cyminum</i> L.	
	Dec., 4- Mar., 9**				
Marjoram	Abnoub	<i>Origanum majorana</i> L.	Lamiaceae	Jan., 5-Mar., 22*	Annual
				Dec., 4-Mar., 9**	
Marjoram	Abnoub	<i>Origanum majorana</i> L.	Lamiaceae	Dec., 21-Aug., 15*	Annual
				Dec., 4-Aug., 22**	
Dill	Shotb	<i>Anethum graveolens</i> L.	Apiaceae	Jan., 26-Mar., 22*	Seasonal
				Jan., 10-Apr., 27**	
Henna	Abnoub	<i>Lawsonia inermis</i> L.	Lythraceae	Dec., 21-Aug., 15*	Annual
				Dec., 4- Aug., 22**	

### Effect of Host Plants on The Biology of The Cowpea Aphid, *Aphis craccivora* Koch under A Constant Temperature:

Various biological parameters of *Aphis craccivora* Koch were studied on 5 different medicinal and aromatic host plants; coriander, cumin, marjoram, dill and henna, in addition to broad bean plants, *Vicia faba* L., as a primer host, under certain laboratory conditions.

#### 1. Aphid Culture:

Aphids' colony were established by a single virginoparous apterous female collected from an infested field of faba bean plants, grown in the experimental farm of the Plant Protection Department, Faculty of Agriculture, Assiut University. Aphids were kept in an incubator at  $22 \pm 1$  °C, relative humidity of  $55 \pm 5\%$  and 16 L: 8 D photoperiod in the laboratory. The culture was maintained for 12 months before using in the biological experiments.

#### 2. Statistical Analysis:

Differences in nymphal development times, adult life span, fecundity, and daily reproduction on each host plant were tested by analysis of variance (ANOVA). If significant differences were detected, multiple comparisons were made using Tukey's HSD multiple range test ( $P < 0.05$ ).

Indices of efficiency (IE) for the development of the different stages of *A. craccivora* were calculated according to the formula of Khattat and Stewart (1977):

$$\text{Indices of Efficiency (IE)} = \text{SP}/\text{Tp, where}$$

Where S is the percentage survival, T is the time required for development in days and P is the host plant.

The obtained data were also used to calculate the following fecundity table aspects according to Birch (1948):

### Effect of Host Plants on Some Physiological Parameters of The Cowpea Aphid, *Aphis craccivora* Koch:

#### 1. Preparation of Samples for Biochemical Studies:

Reared aphids on different host plants (coriander, henna and bean) were collected after reaching the adult stage (1<sup>st</sup> generation), for different enzymatic and biochemical studies. Then, these insects were homogenized in sodium phosphate buffer (pH: 7.00) and centrifuged at 10000 r.p.m. for 15 minutes at 4 °C. The supernatants were used for different physiological assays, using a spectrophotometer.

#### 2. Enzymes Assay:

##### 2.1. Assay of Superoxide-Dismutase (SOD) Activities:

The activity of superoxide dismutase (SOD) of different groups was measured based on the inhibitory action of SOD on epinephrine oxidation at 480 nm (Misra and

Fridovich, 1972).

### 2.2. Assay of Catalase Activity (CAT):

CAT activity was determined by the procedure of Luck (1963) based on its ability to decompose hydrogen peroxide.

### 2.3. Assay of $\alpha$ -amylase Activity:

$\alpha$ -Amylase activity in aphids was determined using kits (Biodiagnostic, Egypt), according to the method of Caraway (1959).

### 2.4. Assay of Lipase Activity:

Lipase activity was determined using kits (Labcare Diagnostics), according to the method of Tietz *et al.* (1995).

## Determination of Total Protein, Carbohydrate and Lipid Content:

### 1. Determination of Total Protein:

Total protein was assayed according to the method of Lowry *et al.* (1951) as follows:

### 2. Determination of Total Lipid:

The determination of total lipids was carried out with a test kit for total lipids (Biodiagnostic, Egypt). The method, described by Zöllner and Kirsch (1962), was originally developed for the determination of serum lipids, so it was adjusted following Barnes and Blackstock (1973) who tested its suitability for analyzing tissues of marine animals.

### 3. Determination of Total Carbohydrate:

The Carbohydrate content of aphids was assayed by the author on reagent after hydrolysis in HCL (4N) for 2h in a boiling water bath (Van-Handel, 1965).

### Statistical Analysis:

The results are expressed as means  $\pm$  SE. Chi-square or one-way analysis of variance (ANOVA) tests were used to assess the significance of differences between the samples, according to the sample size.

## RESULTS

### 1. Effect of Host Plants on The Biology of The Cowpea Aphid, *Aphis craccivora* Koch under Certain Laboratory Conditions:

The biological parameters of the cowpea aphid, *A. craccivora* were studied on different host plants, at certain laboratory conditions (at  $22 \pm 1$  °C, relative humidity of  $55 \pm 5\%$  and 16 L: 8 D photoperiod). After transferring aphids to different host plants, they showed different survival rates. As described, coriander, henna and bean (*Vicia faba* L.) plants were the only suitable host plants for *A. craccivora* Table (2).

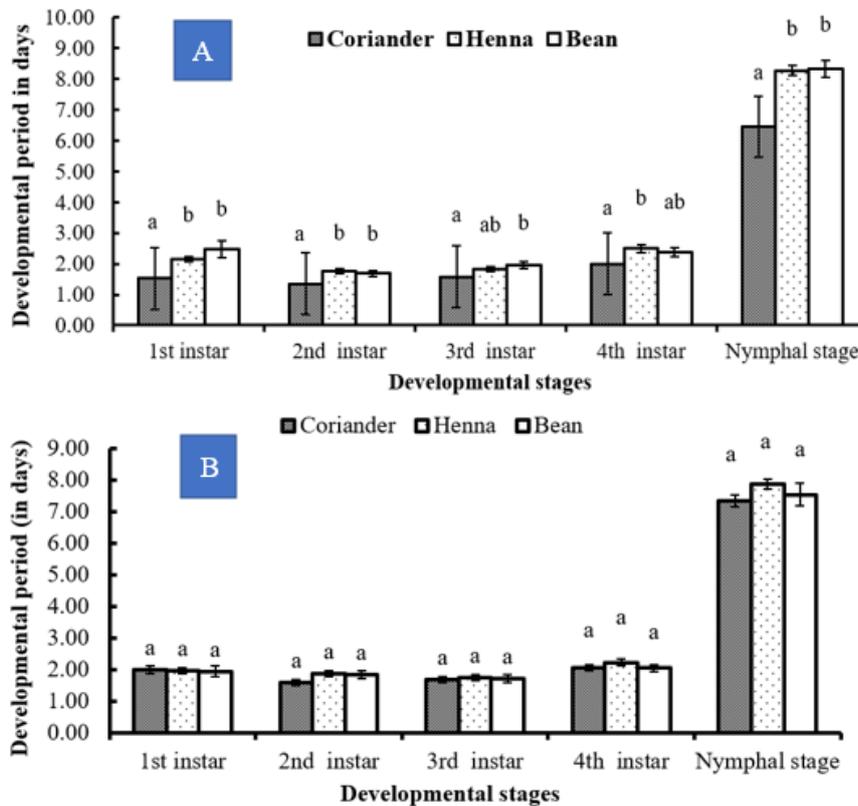
**Table 2:** Survival percentages of *A. craccivora* reached adult stage on different host plants.

Host plants	Survival %	
	1 <sup>st</sup> generation	2 <sup>nd</sup> generation
1- Coriander	88 %	84 %
2- Cumin	22 %	0 %
3- Marjoram	0 %	0 %
4- Dill	12 %	33%
5- Henna	92 %	87 %
6- Bean	84 %	81 %

**2.Effect of Host Plants on the 1<sup>st</sup> generation and 2<sup>nd</sup> generation:**

**2.1. 1<sup>st</sup> generation:**

*A. craccivora* nymphal stages passed through four instars when reared on coriander, henna and bean plants till reaching the adult stage showed different mean developmental stages duration on the three tested plants (Fig. 1 a). The mean duration of the first, Second, Third, and Fourth nymphal instars were 1.53, 2.16 and 2.48; 1.35, 1.78 and 1.68; 1.58, 1.83 and 1.95; and 2.00, 2.50 and 2.38 days when reared on coriander, henna and bean, respectively. The nymphs in the first nymphal instar reared on coriander had the shortest developmental time, compared with those on henna and bean. The Second nymphal instar coriander had the shortest developmental duration, and henna and bean plants. However, in the Third nymphal instar coriander plants were significantly different from those henna and bean plants. The significant differences between coriander and the other two plants continued during the Fourth nymphal instar. Total nymphal stage duration, considered from birth of 1st instar to the end of the 4th instar, had the shortest duration on coriander 6.45 days, followed by henna host plant 8.28 days, then bean plants 8.33 days (Fig. 1 a).



**Fig. 1 (a):** Developmental periods (in days) of different nymphal stages of *A. craccivora* reared on coriander, henna and bean plants, during 1st generation. **(b):** Developmental periods (in days) of different nymphal stages of *A. craccivora* reared on coriander, henna and bean plants, during 2<sup>nd</sup> generation. Data are presented as mean± SE, P< 0.05 and was different letters considered significant.

**2.2. 2<sup>nd</sup> generation:**

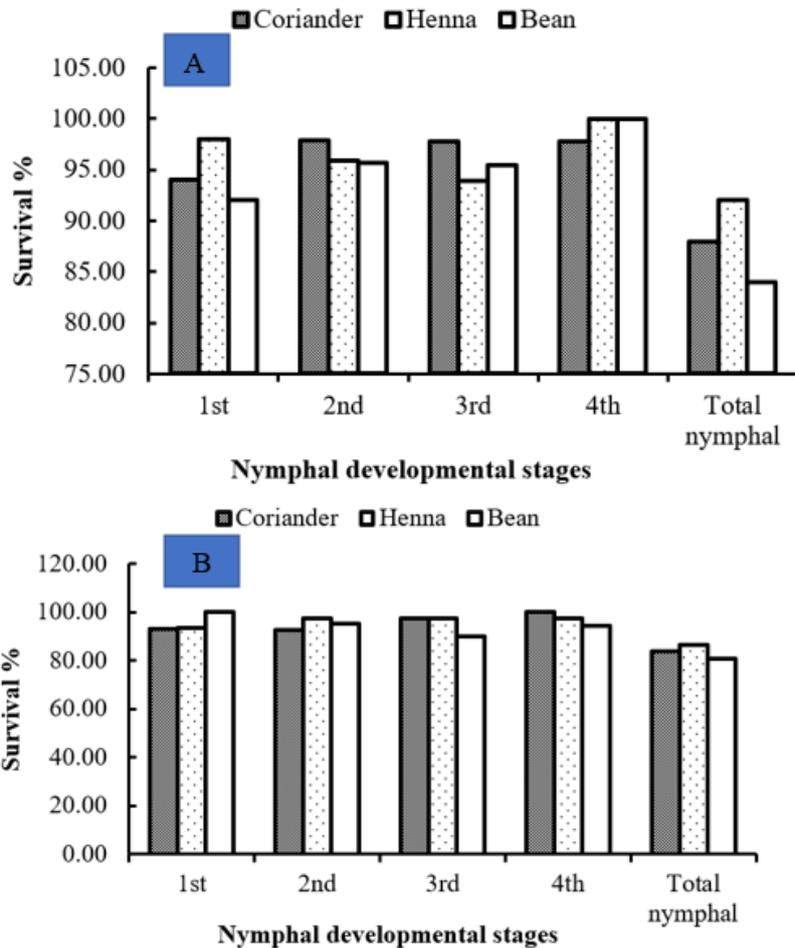
Data obtained from rearing *A. craccivora* on different host plants during the 2nd generation; revealed lack of significant differences between studied stages of aphids. The mean durations of the first, 2nd, third, and fourth nymphal instars on coriander, henna and bean host plants were 2.00, 1.98 and 1.95; 1.59, 1.88 and 1.85; 1.69, 1.75 and 1.72; and 2.06, 2.23 and 2.06 days, respectively. While the coriander host plant recorded the shortest

duration, the bean was the longest. Apparently, coriander and bean host plants had the same duration, while henna recorded the shortest duration in the Fourth nymphal instar. The Total nymphal had the shortest mean duration on coriander host plants (7.33 days). Meanwhile, henna recorded the longest mean duration with an average of 7.87 days, followed by bean host plant which had an average of 7.53 days (Fig. 1b).

### 3. Nymphal Survival Percentage and Indices of Efficiency (IE) of Nymphal Instars:

#### 3.1.1<sup>st</sup> generation:

Survival ratios were (94.00, 97.87, 97.82, 97.78 and 88.00 %) on coriander, (98.00, 95.91, 93.88, 100.00 and 92.00 %) on henna and (92.00, 95.65, 95.45, 100.00, 84.00 %) during the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and total nymphal stage, respectively. The highest and lowest survival percentage (92.00 and 84.00%) was recorded on henna plants and bean plants respectively (Fig. 2 a). The highest and lowest value of indices of efficiency was recorded on coriander bean, and henna host plants (13.63 and 10.88), respectively (Fig. 3 b).

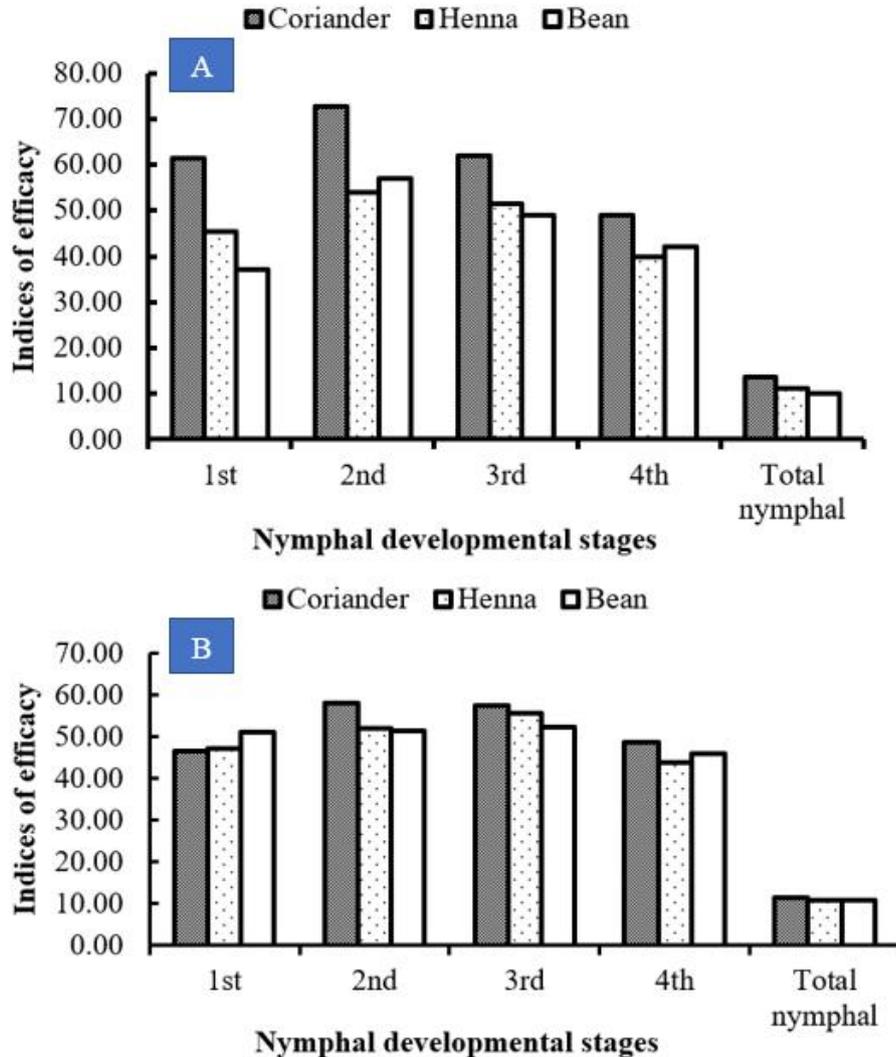


**Fig.2 (a):** Survival percentages of different nymphal stages of *A. craccivora* reared on coriander, henna and bean plants, during 1<sup>st</sup> generation and **(b):** during 2<sup>nd</sup> generation.

#### 3.2.2<sup>nd</sup> generation:

Concerning *A. craccivora* survival percentage, the survival rates of nymphal instars and total nymphal stage were (93.02, 92.50, 97.50, 100.00 and 83.72%) on coriander; (93.33, 97.62, 97.56, 97.50 and 86.67%) on henna and (100.00, 95.24, 90.00, 94.44 and 80.95%) on bean host plants. The highest survival percentage of the total nymphal stages was obtained on henna hosts, while the shortest was recorded on bean host plants (Fig. 2 b). It was clearly shown that the highest and lowest value of the index of efficiency was recorded on the coriander and bean host plants (11.42 and 10.75),

respectively. Obviously, indices of efficiency (IE) for developmental nymphal instars decreased for coriander and henna host plants, while they increased for bean host plants during the 2<sup>nd</sup> generation (Fig. 3b).

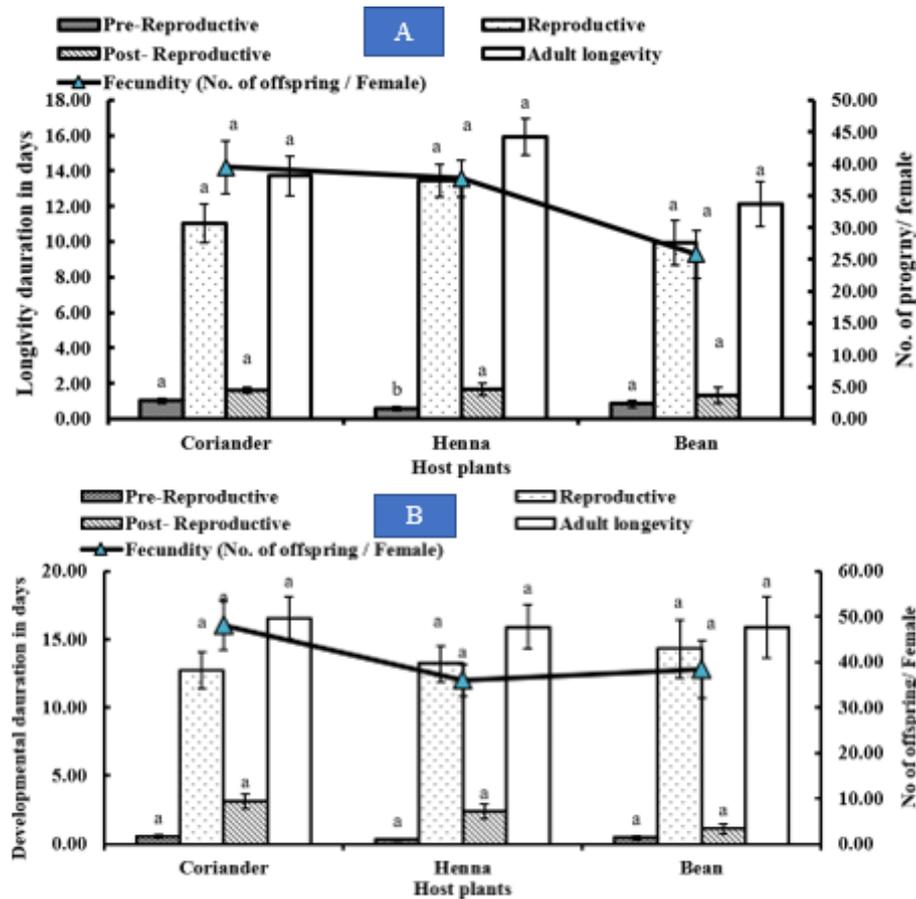


**Fig. 3 (a):** Indices of efficacy (IE) of the immature stages of *A. craccivora* reared on coriander, henna and bean host plants, during 1<sup>st</sup> generation and **(b):** during 2<sup>nd</sup> generation.

**4.Effect of Host Plants on Reproductive Ability, Adult Longevity and Fecundity:**

**4.1.1<sup>st</sup> generation:**

Adult longevity in the pre-reproductive stage of *A. craccivora* showed significant differences between data. The Adults started to give the first birth, Reproductive, and Post-reproductive period respectively after 1.02, 0.57 and 0.86; 11.05, 13.46 and 9.95; and 1.61, 1.67 and 1.33 on coriander, henna and bean host plants, respectively. Although the pre-reproductive period extended the longest on coriander host plants, reproductive and post-reproductive periods of cowpea aphids reared on henna host plants were the longest duration of the three host plants, followed by coriander then bean plants. Adult longevity took the same trend of insignificance as reproductive and post-reproductive periods between the three host plants. Also, Adults reared on henna host plants lived much more than those on other hosts. The number of offspring per female of *A. craccivora* revealed insignificant differences between the three host plants. Fecundities were  $39.45 \pm 4.19$ ,  $37.70 \pm 2.86$  and  $25.81 \pm 3.69$  nymphs/female on coriander, henna and bean host plants (Fig. 4 a).



**Fig. 4(a):** Mean durations (in days) and fecundity (progeny/ female) of adult stage of *A. craccivora*, reared on coriander, henna and bean host plants, during 1<sup>st</sup> generation and **(b):** during 2<sup>nd</sup> generation. Data are presented as mean $\pm$  SE,  $P < 0.05$  and different letters was considered significant.

#### 4.2.2<sup>nd</sup> generation:

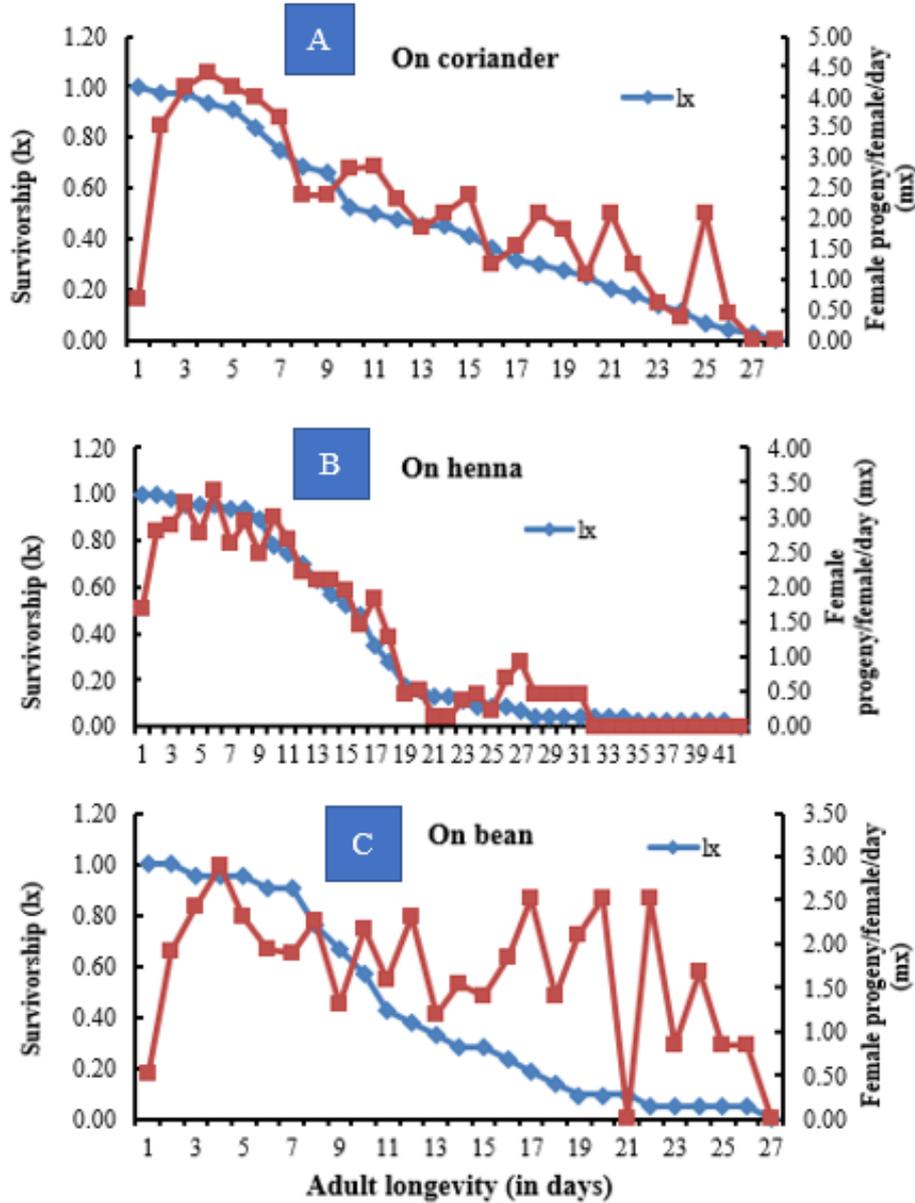
The host plants had no significant effect on females of *A. craccivora* aphid's adult reproductive periods. Pre-reproduction period duration decreased during the 2<sup>nd</sup> generation on different host plants when compared with the 1<sup>st</sup> generation. Time estimated at Pre-reproduction, Reproduction and post-reproduction for cowpea adults to give labor was; 0.53, 0.31 and 0.47; 12.69, 13.21 and 14.29; and 3.14, 2.38 and 1.12 days when reared on coriander, henna and bean host plants, respectively. In different adult stages, adult longevity increased obviously during this generation than the previous, recording coriander has the longest duration followed by henna then bean as the shortest. The durations were 16.56, 15.90 and 15.88 on coriander, henna and bean host plants, respectively. An increment of aphid fecundity was marked down at this generation on coriander and bean host plants. On the coriander host plant, the number of offspring deposited per female was 48.08 nymph/female and listed as the largest. The lowest number was recorded on henna (35.97) nymph/female, while on bean it was 38.47 nymph/female (Fig. 4 b).

### 5. Effect of Host Plants on Age-Specific Survival Rate ( $l_x$ ) and Age-Specific Fecundity Rate ( $m_x$ ):

#### 5.1.1<sup>st</sup> generation:

It could be noted that the survivorship ( $l_x$ ) for *A. craccivora* female age was higher when reared on henna than other host plants. In addition, adults' mortality began on the 2<sup>nd</sup> day on coriander and bean, while it started on the 3<sup>rd</sup> on henna. The survival patterns on henna host plants declined to 50% after about 16 days, whereas it took about 11 days to

decline to 50% of the population on coriander and bean. Also, the age-specific fecundity per day ( $m_x$ ) of cowpea aphids was recorded as the highest on the coriander host plant (4.35 female/female/day) in the 4<sup>th</sup> day. On the other hand, on henna, the maximum reproduction rate per female per day ( $m_x$ ) was 3.39 female/female/day on the 6<sup>th</sup> day, while the maximum was on the 4<sup>th</sup> day recording 2.90 female/female/day, on bean (Figs. 5 a,b &c).

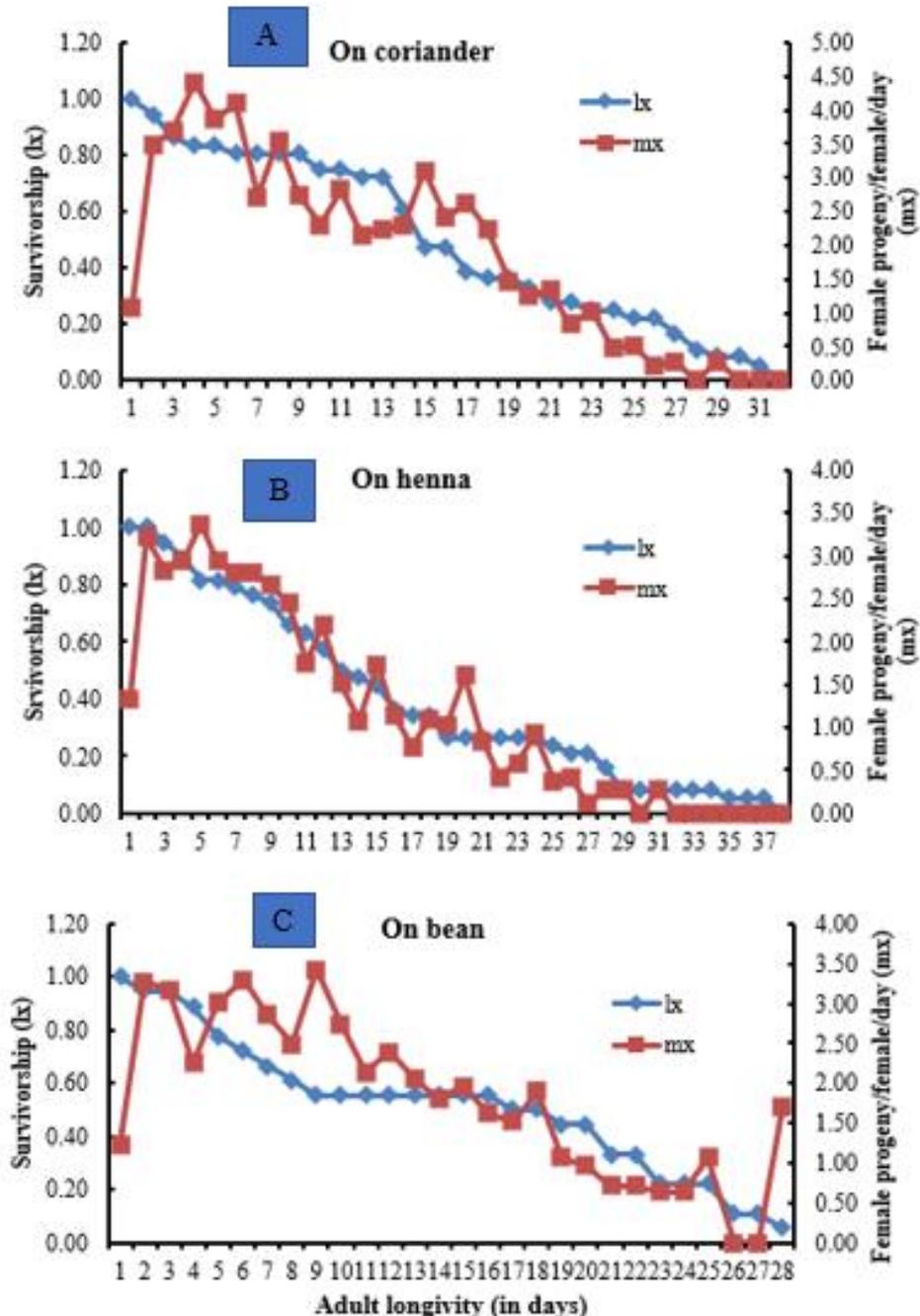


**Fig. 5 (a, b &c):** Age-specific survivorship ( $l_x$ ) and age-specific fecundity rate ( $m_x$ ) of *A. craccivora* reared on coriander, henna and bean host plants, during 1<sup>st</sup> generation.

**5.2.2<sup>nd</sup> generation:**

Age-specific survivorship ( $l_x$ ) tended to have the same behavioral pattern as the 1<sup>st</sup> generation. Adults reared on henna host plants had the longest survival rate, compared with coriander and bean host plants. However, 50% mortality of the pest adult stage occurred the soonest on henna after about 13 days, while bean had the latest. Adults' mortality also, began from the 2<sup>nd</sup> day on coriander and bean host plants, while it started on the 3<sup>rd</sup> day on henna. The data also estimated the maximum age-specific fecundity rate ( $m_x$ ) of cowpea aphids on each host plant. The greatest number of progenies for the females reared on

coriander was approximately 4.41 female/female/day observed after 4 days from the adult emergence. In addition henna and bean host plants maximum ( $m_x$ ) were 3.38 and 3.4 female/female/day noticed on the 5<sup>th</sup> and 9<sup>th</sup> day of adult stages, respectively (Figs. 6 a,b &c).



**Fig. 6 (a, b and c):** Age-specific survivorship ( $l_x$ ) and age-specific fecundity rate ( $m_x$ ) of *A. craccivora* reared on coriander, henna and bean host plants, during 2<sup>nd</sup> generation.

## 6. Effect of Host Plants on Net Reproductive Rate ( $R_0$ ), Generation Time (GT), Population Doubling Time (DT) and Rate of Increase:

### 6.1. 1<sup>st</sup> generation:

Data in Table (3) clearly shows that aphids reared on bean host plants had a lower (21.72) net reproductive rate ( $R_0$ ) as compared with coriander and henna host plants (35.37 and 35.28, respectively). It is evident that the population of *A. craccivora* reared on

coriander and/or henna host plants could be increased about 1.6 times in the course of one generation, as compared with a bean host plant. The duration of one generation (in days) of *A. craccivora* lasted about 13.53, 15.74 and 15.83 on coriander, henna and bean host plants, respectively. The population of *A. craccivora* had the capacity to double itself every 1.25, 1.61 and 3.46 days, on coriander, henna and bean host plants, respectively **table (3)**. The values of ( $r_m$ ) of cowpea aphids reared on coriander and/or henna (0.5528 and 0.4304) host plants were about 1.6 times higher than those reared on bean host plants (0.2001). It was found that the population of *A. craccivora* had the ability to multiply about 1.7382, 1.5378 and 1.2215 times per female per day when reared on coriander, henna and bean host plants, respectively. When the values of finite rate of increase ( $\lambda$ ) are taken into consideration, we can find that a population of 10 females of cowpea aphids could increase in a duration of one week to become 479, 203 and 40 individuals reared on the previous host plants Table (3).

**Table 3:** Life table parameters of *A. craccivora* when reared on coriander, henna and bean host plants, during 1<sup>st</sup> generation.

Host plants		Life table parameters				
		Generation time (GT)	Doubling time (DT)	Net reproductive ( $R_0$ )	Rate of increase	
					Intrinsic ( $r_m$ )	Finite ( $\lambda$ )
1 <sup>st</sup> generation	Coriander	13.53	1.25	35.37	0.5528	1.7382
	Henna	15.74	1.61	35.28	0.4304	1.5378
	Bean	15.83	3.46	21.72	0.2001	1.2215

## 6.2. 2<sup>nd</sup> generation:

Net reproductive rate ( $R_0$ ) of *A. craccivora* of aphids were calculated to be 40.02, 30.15 and 31.28 on coriander, henna and bean host plants, respectively. It is evident that the population of *A. craccivora* reared on the coriander host plant could be increased about 1.3 and 1.2 times in the course of one generation, as compared with henna and bean host plants, respectively. The generation time was recorded as 15.60, 15.72 and 16.64 days on coriander, henna and bean, respectively. The Population doubling time (DT) was estimated at 2.93, 2.87 and 3.35 days on coriander, henna and bean host plants, respectively Table (4). The innate capacities to increase ( $r_m$ ) of cowpea aphids were 0.2365, 0.2166 and 0.2069 reared on coriander, henna and bean host plants, respectively. Coriander (the highest) was 1.14 times higher than that observed on beans (the lowest). On the other hand, when ( $r_m$ ) values were converted to the finite rate of increase ( $\lambda$ ), It was found that the population of *A. craccivora* had the ability to multiply about 1.2668, 1.2419 and 1.2298 times per female per day when reared on coriander, henna and bean host plants, respectively Table (4).

**Table (4):** Life table parameters of *A. craccivora* when reared on coriander, henna and bean host plants, during 2<sup>nd</sup> generation.

Host plants		Life table parameters				
		Generation time (GT)	Doubling time (DT)	Net reproductive ( $R_0$ )	Rate of increase	
					Intrinsic ( $r_m$ )	Finite ( $\lambda$ )
2 <sup>nd</sup> generation	Coriander	15.60	2.93	40.02	0.2365	1.2668
	Henna	15.72	2.87	30.15	0.2166	1.2419
	Bean	16.64	3.35	31.28	0.2069	1.2298

### 7. Effect of Host Plants on Superoxide Dismutase Activity (SOD) and Catalase Activity (CAT) of the Cowpea Aphid, *Aphis craccivora* Koch

Results presented in Table (5) showed that SOD and Catalase activity was significantly affected within cowpea aphids and within *A. craccivora* with plant shifting, ( $P= 3.16E-09$  and  $P= 2.09E-11$ ) respectively with different host plants, The aphids fed on henna plants had the conc. level ( $0.49\pm 0.048$  and  $35.68\pm 4.21b$ ), coriander plants ( $0.03\pm 0.005$  and  $63.92\pm 10.52a$ ), while, bean plants had the least activity ( $0.02\pm 0.002a$  and  $28.54\pm 5.96c$ ) respectively.

### 8. Effect of Host Plants on $\alpha$ -amylase, and Lipase Enzyme of the Cowpea Aphid, *Aphis craccivora* Koch:

The activity of  $\alpha$ -amylase enzyme and activities of lipase in the homogenates of cowpea aphids was clearly not affected with different host plants, ( $P= 0.995$  and  $P= 0.998$ ) respectively. Activities of the three plants; coriander, henna and bean were found to be  $0.12\pm 0.037$ ,  $0.13\pm 0.045$  and  $0.15\pm 0.027$ ; and  $0.06\pm 0.018$ ,  $0.06\pm 0.002$  and  $0.07\pm 0.006$ , respectively Table (5)

### 9. Effect of Host Plants on The Energy Sources (Total protein assay, Total lipids and Total Carbohydrates Content):

The total protein, total lipids and total carbohydrate contents of cowpea aphids homogenates fed on the different host plants were assessed to be insignificant ( $P= 0.51$ ), a significant difference ( $P$  value was  $0.049$ ) and no significant ( $P= 0.98$ ) respectively. Protein contents were estimated as  $1.18\pm 0.09$ ,  $1.10\pm 0.06$  and  $1.07\pm 0.05$ ;  $2.51\pm 0.171$ ,  $3.21\pm 0.230$  and  $2.66\pm 0.164$ ; and  $0.56\pm 0.08$ ,  $0.54\pm 0.05$  and  $0.55\pm 0.07$  of aphids fed on coriander, henna and bean, respectively Table (5).

**Table 5:** Different enzymatic activities (antioxidants and digestive enzymes) and energy sources of *A. craccivora* on studied host plants; coriander, henna and bean.

Category		Host plants		
		Coriander	Henna	Bean
Antioxidant enzymes	SOD unit/mg protein	$0.03\pm 0.005^a$	$0.49\pm 0.048^b$	$0.02\pm 0.002^a$
	CAT unit/mg protein	$63.92\pm 10.52^a$	$35.68\pm 4.21^{ab}$	$28.54\pm 5.96^b$
Digestive enzyme	Amylase unit/mg protein	$0.12\pm 0.037^a$	$0.13\pm 0.045^a$	$0.15\pm 0.027^a$
	Lipase unit/mg protein	$0.06\pm 0.018^a$	$0.06\pm 0.002^a$	$0.07\pm 0.006^a$
Energy sources	Total protein mg/ml	$1.18\pm 0.09^a$	$1.10\pm 0.06^a$	$1.07\pm 0.05^a$
	Total lipids mg/ml	$2.51\pm 0.17^a$	$3.21\pm 0.23^b$	$2.66\pm 0.16^{ab}$
	Total Carbohydrates mg/ml	$0.56\pm 0.08^a$	$0.54\pm 0.05^a$	$0.55\pm 0.07^a$

Data are presented as mean  $\pm$  SE.  $P < 0.05$  was considered significant. Similar letters denoted within the same row are considered insignificant values.

## DISCUSSION

The bionomics of the population on other medicinal and fragrant plants was also studied, along with the broad bean (*Vicia faba* L.). Given that the host used for raising *A. craccivora* clones is known to have an impact on subsequent performance, this plant was selected as the neutral host plant. Our findings showed that marjoram plants have a potent deterring impact on aphids because terpinene-4-ol, (+)-terpineol, linalol, (+)-sabinene and its hydrate, as well as terpinene, are the primary components of marjoram oil (Nowak & Ogonowski, 2010 and Danciewicz *et al.*, 2012). Furthermore, *A. craccivora* had a poor survival rate on the host plants' dill and cumin. This may be connected to the morphology, secondary chemical composition, and nutritional content of these plants, all of which have an impact on the development, growth, fecundity, and survival of herbivorous insects

(Norris and Kogan, 1980).

These plants may contain component substances or physiological barriers that greatly reduced eating, and as a result, the growth and reproductive capacity of cowpea aphids. Our findings are supported by Hosseini-Tabesh *et al.* (2015); during the first generation, aphids performed better on coriander plants than henna and bean. In comparison to the other two hosts, coriander had much faster nymphal stage development periods. In this context, Ranila *et al.* (2015) discovered that when they raised *A. gossypii* on coriander plants, the average developmental periods of the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> nymphal instars and the total nymphal period were in short days. Furthermore, Choudhary *et al.* (2013) showed that the duration of the coriander aphids' 1<sup>st</sup> nymphal instar, second nymphal instar, and third nymphal instar was only a few days.

The first instar lasted the longest on bean plants, whereas the fourth instar lasted the longest on coriander and henna. These findings were at odds with those made by Nasser & Abdel-Rahman (1999), who claimed that the second instar's length was the longest. As for the survival percentage of *A. craccivora* on the three cultivars, the data revealed a generally increasing in survival ratios during different developmental stages. The coriander host plant had the highest index of efficiency (IE) throughout the various nymphal instars, whereas bean plants had the lowest value for the entire nymphal stage. These findings suggested that henna and bean host plants might not be as beneficial as coriander host plants. These are partly in accordance with Ali *et al.* (2002) and Ranila *et al.* (2015) who noted that the cowpea aphid's efficiency index at 22°C was 15.23. There was no statistically significant difference in the adult stage between different host plants with regard to the lifetime and fertility of *A. craccivora* at each host plant.

According to Van Lenteren and Noldus (1990), an insect's host plant adaptability can be shown in its reduced pre-reproductive phase and higher reproductive potential. This could be an indication that coriander was a better host plant for aphids than other plants. The results showed that host plants' mature longevity and fertility were not significantly different from one another. This partially accords with Singh and Singh (2015), who found no appreciable variation in the adult *A. gossypii* longevity when raised on three crops. Additionally, on the 4<sup>th</sup> day, the cowpea aphid's age-specific fecundity per day (mx) was highest on the coriander and bean host plants. The obtained data further support the widely held belief that the progeny should peak at the start of the reproduction period (Taheri *et al.*, 2010 and Ranila *et al.*, 2015).

The link between fecundity, generation time, and survival is expressed by the value of (rm) (Birch, 1948). The value of the net reproduction rate is significant because it reflects the quality of the host plant and the ability of a female to produce offspring (Bernardi *et al.*, 2012). The greatest (rm) reveals the best reproductive potential if (rm) is a gauge of environmental appropriateness. According to a dating assessment, the coriander host plant appeared to be the most advantageous host. Similar findings were made by Taheri *et al.* (2010). Additionally, Soffan and Aldawood (2014) discovered that even toward the end of their reproductive cycle, cowpea aphid fertility in whole-plant faba beans (Misr1) remained high. These phenomena enhance generation time value while lowering the intrinsic rate of rising value. On the other hand, *A. craccivora* grown on broad bean (*V. faba*) with some level of resistance had very low rm values, as revealed by Laamari *et al.* (2008). These rm values were lower than those found in this study, most likely as a result of the many environmental factors, including temperature, that was present during the investigations (Lu *et al.*, 2016; Hu *et al.*, 2017).

Additionally, Singh and Singh (2015) proposed three hypotheses that, taken individually or collectively, could explain the observed variations in *A. gossypii* performance on various host plants. First, different host plants have different nutritional

values for *A. gossypii*; second, the use of a new host plant depends on the aphid's experience because it takes time for the aphid to adapt to a new host; and third, there are genetically distinct forms or host races of *A. gossypii* that have different propensities for colonizing different host plants. The results of aphids from the second generation obtained are consistent with the records previously indicated by Ranila *et al.* (2015) and Hosseini-Tabesh *et al.* (2015). Overall findings showed that henna and bean plants were less suitable for cowpea aphids than coriander and cumin plants. The mechanisms of host specialization are influenced by a complex mix of biotic and abiotic interactions, behavior, and genetic factors. This could impair an aphid's performance in the field (Forister *et al.*, 2012).

Aphid insects adjust biochemically to high harmful concentrations of ROS produced by plants, changing their antioxidant defense mechanisms (Lukasik *et al.*, 2015; Abdelsalam *et al.*, 2016). For herbivorous insects, removing harmful hydrogen peroxide is crucial to preventing oxidative damage (Lukasik *et al.*, 2012; Deng *et al.*, 2013). Among the most important enzymes in the ROS cleaning system, CAT and SOD can efficiently prevent ROS from causing harm. In insects, they serve as complementing enzymes. Both SOD and CAT activities were dramatically increased by several host plants in the current investigation. The activities of SOD and CAT enzymes were found to be induced after an insect was transferred to a secondary host (Lukasik and Golawska, 2013).

Aphids have higher levels of antioxidant enzymes, which may be an adaptation to new host plants. According to Lee and Berenbaum (1993), lepidopteran larvae have increased levels of SOD and CAT activity when they feed on plant species (Apiaceae, Rutaceae, Asteraceae) that are rich in photodynamic pro-oxidants such as furanocoumarins and b-carboline alkaloids. Alkaloids, flavonoids, polyphenols, glycosides, saponins, tannins, quinines, resins, and sterols were found in the phytochemical screening of henna (Wagini *et al.*, 2014). These secondary metabolites may have induced the activation of antioxidant enzymes in aphids (Belfeki *et al.* 2016). After transferring insects to secondary hosts, Lukasik & Golawska (2013) discovered that SOD activity was quickly elevated whereas CAT activity was decreased. Long-term insect feeding led to a progressive increase in CAT and a gradual drop in SOD. According to these observations, the superoxide radicals were quickly converted into hydrogen peroxide after the induction of SOD, and a higher intracellular concentration of H<sub>2</sub>O<sub>2</sub> may have caused CAT activity in insects.

Therefore, these variations in enzyme activity between different insect species may be a result of their various feeding strategies and food sources. It is evident that the diverse host plants had no discernible impact on the activities of these digestive enzymes lipase and  $\alpha$ -amylases (Kaur and Gupta, 2015). On the other hand, the estimated activities on the examined plants exhibited approximations of values. This is consistent with Gutierrez *et al.* (1990), who concluded that wheat plants had no inhibitory impact on aphids'  $\alpha$ -amylase while substantial inhibition was seen against other pests. Declared outcomes revealed negligible nutritional values for total protein, and carbohydrate and a considerable impact on the total lipid content. Ahsaei *et al.* (2013) found the host plant and other stressors that an aphid can encounter have an impact on its energy sources. Rowland *et al.* (2016) found the difference in total lipid content may be explained by variations in the nutritional value of the studied host plants. In contrast, the results showed only small changes in the lipase enzyme levels among the host plants. It's interesting to note that among the three host plants, the total lipid value of the aphid insects was larger than the total protein and carbohydrate content. According to Ahsaei *et al.*, (2013) this may be because of the high energy content of the substance. Additionally, the total amount of protein was larger than the total amount of carbohydrates. This may be because the protein in insects is thought to be necessary for growth, maintenance, morphogenesis, and reproduction rather than as a

source of energy (Ahsaei *et al.*, 2013).

### Conclusion

The coriander plant was the most preferred host plant for the aphid, *Aphis craccivora* when compared with henna and bean plants. So, coriander plants should not be cultivated near bean plants in order not to increase infestation with aphids.

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