NARDI FUNDULEA, ROMANIA
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ROMANIAN AGRICULTURAL RESEARCH, NO. 31, 2014
Print ISSN 1222-4227; Online ISSN 2067-5720

EFFECT OF SEVEN CANOLA GENOTYPES ON CABBAGE APHID *BREVICORYNE BRASSICAE* GROWTH PARAMETERS

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ABSTRACT

Developmental time and reproduction of cabbage aphid *Brevicoryne brassicae* (L.) were evaluated on leaves of seven genotype of canola (*Brassica napus* L.) ("Modena", "Geronimo", "Opera", "Sunday", "Dexter", "Zarfam" and "Okapi") at a constant temperature of 22.5 °C. Total developmental time of *B. brassicae* was the shortest (8.38 days) on "Geronimo and the longest (9.16 days) on "Opera" and "Okapi". Production longevity time of aphid was the shortest (11.66 days) on "Opera", and the longest (17.13 days) on "Geronimo". Net reproductive rate was highest (45.46 nymph) on "Geronimo" and lowest (21.33 nymph) on "Okapi". Intrinsic rate of increase was 0.274 on "Geronimo", followed by 0.249 on "Modena", 0.246 on "Dexter", 0.227 on "Opera", 0.227 on "Zarfam", 0.221 "Sunday" and 0.204 on "Okapi". "Geronimo" was the most susceptible host plant for the cabbage aphid and "Okapi" showed resistance to cabbage aphid.

Key words: Antibiosis; *Brassica napus*; developmental time; genotype, intrinsic rate of increase.

Abbreviations:
IPM (Integrated pest management), R0 (Net rate of reproduction), rm (Intrinsic rate of increase), DT (Doubling time), T (Generation time), λ (Finite growth rate), L: D (Light:Dark), x (each age interval per day), lx (age-specific survival rate), mx (nymphs per female per day female/female/day), r (intrinsic rate of increase), α (first generation day).

INTRODUCTION

Colza (*Brassica napus* L.) is one of the prominent planted oil seed in Iran. This plant has good agricultural and food nourishment properties, such as resistance to drought, cold and salinity stresses and low level of cholesterol (Ahmadi and Javid-Far, 1998; Sojoodi, 2000). Cabbage waxy aphid *Brevicoryne brassicae* (L.) is as one of the major pests of the Brassicaceae family, can be found in many countries of the world (Karazmoodeh and Zandi, 2013). Cabbage aphid can attack to the host plant leaves, stems, and seeds and transmits dangerous viruses (Burges et al., 2000; Jayama et al., 2003). This aphid is scattered on canola fields (Jamshidi-Kaljahi et al., 2006) and reduced grain yields by 9 to 77% and oil content up to 11% (Ellis, 1993; Ellis et al., 1996). Pesticide application is the traditional method for aphid control. High proportion of pesticides is toxic and has adverse effects on human health, wildlife, local food sources, beneficial insects and biodiversity (Bissdorf, 2008). Furthermore, cabbage aphids often select varieties with more waxy leaves and are hidden between leaves, so limiting the efficiency of chemical control (Ellis et al., 1996). Therefore, the using of systemic pesticides is inevitable (Schroder and Dombleton, 2001; Umeda and Mcneil, 2000).

Developing environmental-friendly methods, such as deploying insect-resistant varieties to pest control was recommended by scientists (Yue and Liu, 2000; Wang and Tsai, 2000; Sarwar et al., 2002). Resistant varieties decrease production costs and can be integrated with other pest control policies in IPM programs (Maurya, 1998; Kumar and

Received 04 February 2013; accepted 3 February 2014. First online: 10 April 2014. DII 2067-5720 RAR 2014-300

Sharma, 1999). From 401 evaluated germplasm under field and greenhouse conditions, 11 resistant accessions were detected (Ellis et al., 1998). Among four evaluated genotypes, cabbage waxy aphid had the least growth on “PF” (Moharrami-pour et al., 2003). In a greenhouse experiment plants of cabbage, cauliflower were susceptible host plant and broccoli, turnip, rapeseed, showed resistance to cabbage aphid (Ulusoy and Ölmez-Bayhan, 2006). In an evaluation “Lazaco” had the highest antibiotic effect on growth parameters of cabbage aphid (La Rossa et al., 2003). With the aim of identifying the existence of resistance resources, a laboratory study was conducted to evaluate the effects of seven canola genotypes on biological parameters of cabbage aphid. Detected resistant variety(ies) could be used as a resistance source.

MATERIAL AND METHODS

Seven canola genotypes with the names of “Dexter”, “Geronimo”, “Modena”, “Okapi”, “Opera”, “Sunday” and “Zarfam” were planted at 25±1°C, 65±5% R.H., and 14L:10D under laboratory conditions. Soil mixture containing farm soil, sand and fertilizer was used in pots with 8×35×25 cm dimensions and watered once a week. Cabbage aphid used in the experiment was obtained from a caged colony in the laboratory of the Plant Protection and Natural Resources Center of West Azerbaijan province, Urmia and was confirmed by the institute of plant protection of Tehran and reared in the laboratory. Equal numbers of apterous viviparous females were transferred individually to each host plant. When the neonates appeared, except one, other nymphs with mature aphid were removed. Antibiose experiment was conducted in the greenhouse at 24±2°C, RH=60±10% and 16L:8D hours during years 2010-11 in a Completely Randomized Design with 15 replications (La Rossa et al., 2003; Jamshidi-Kaljahi et al., 2006). After nymphs become mature at each pot, time to maturity, generation longevity and mean number of nymphs per female were recorded. To calculate population growth rates the following equation was used (Lotka, 1924):

$$1 = \sum_{\beta}^{\alpha} e^{-rx} l_x m_x$$

Other population parameters were computed as follows (Carey, 1993):

Finite growth rate $\lambda = e^r$, Doubling time $DT = \frac{\ln 2}{r}$ and Mean generation time $T = \frac{LnR_0}{r}$

where: x= each age interval per day, l_x = age-specific survival rate, m_x = nymphs per female per day (female/female/day), R_0 = net reproductive rate, DT= Doubling time, T_0 = mean generation time, r = intrinsic rate of increase, α = first generation day and β = the last day of generation.

Data were analysed for nymph developmental time, adult life span, fecundity, and daily reproduction on genotypes. Means were compared by Least Significant Differences (α= 0.05).

RESULTS

The results of analysis of variance showed that there were significant differences for traits of developmental time, aphid production longevity, R_0, r_m, DT, T and λ ($P \le 0.05$) among the seven genotypes.

Development of immature stages

Development and survivorship for immature instars of *B. brassicae* were determined on seven canola genotype (Figure 1; Table 1). The developmental time of aphid was longest on “Okapi” and “Opera” (9.16 day) and shortest on “Geronimo” (8.38 day) and other genotypes were between them. It seems that differences between genotypes depended on their food quality. La Rossa et al. (2003) reported differences between period of developmental time of cabbage aphid between sensitive (7.50 days) and resistant (11.73 days) canola genotypes. Moharrami-pour et al., (2003) reported different developmental time of cabbage aphid on four canola genotypes. Jamshidi et al. (2006), Ulusoy and Ölmez-Bayhan (2006) obtained similar results on different host plant (Table 1).

Aphid production longevity

The long and short longevity period indicates suitability and unsuitability of host plant, respectively. Highest cabbage aphid longevity was found on “Geronimo” with 17.13 days, while the longevity on “Opera” with 11.66 days was the same significance group with "Okapi" (Table 1). Cabbage aphid had the longest longevity on cauliflower (21.8 days) and the shortest on turnip (6.2 days) (Ulusoy and Ölmez-Bayhan, 2006).

Table 1. Developmental time of *Brevicoryne brassicae* on canola genotypes

Genotype	Developmental time (days) (Mean ± SE)	Aphid production longevity(days) (Mean ± SE)
Modena	8.833 ± 0.110 abc	14.666 ± 0.232 b
Geronimo	8.383 ± 0.152 c	17.133 ± 0.180 a
Opera	9.166 ± 0.128 a	11.666 ± 0.135 d
Sunday	8.833 ± 0.149 bc	13.116 ± 0.180 c
Dexter	8.666 ± 0.141 bc	14.350 ± 0.267 b
Zarfam	9.110 ± 0.170 ab	13.333 ± 0.243 c
Okapi	9.166 ± 0.246 a	12.116 ± 0.167 d

Within columns, means followed by a common letter do not differ significantly (α=0.05, Duncan's multiple range test).

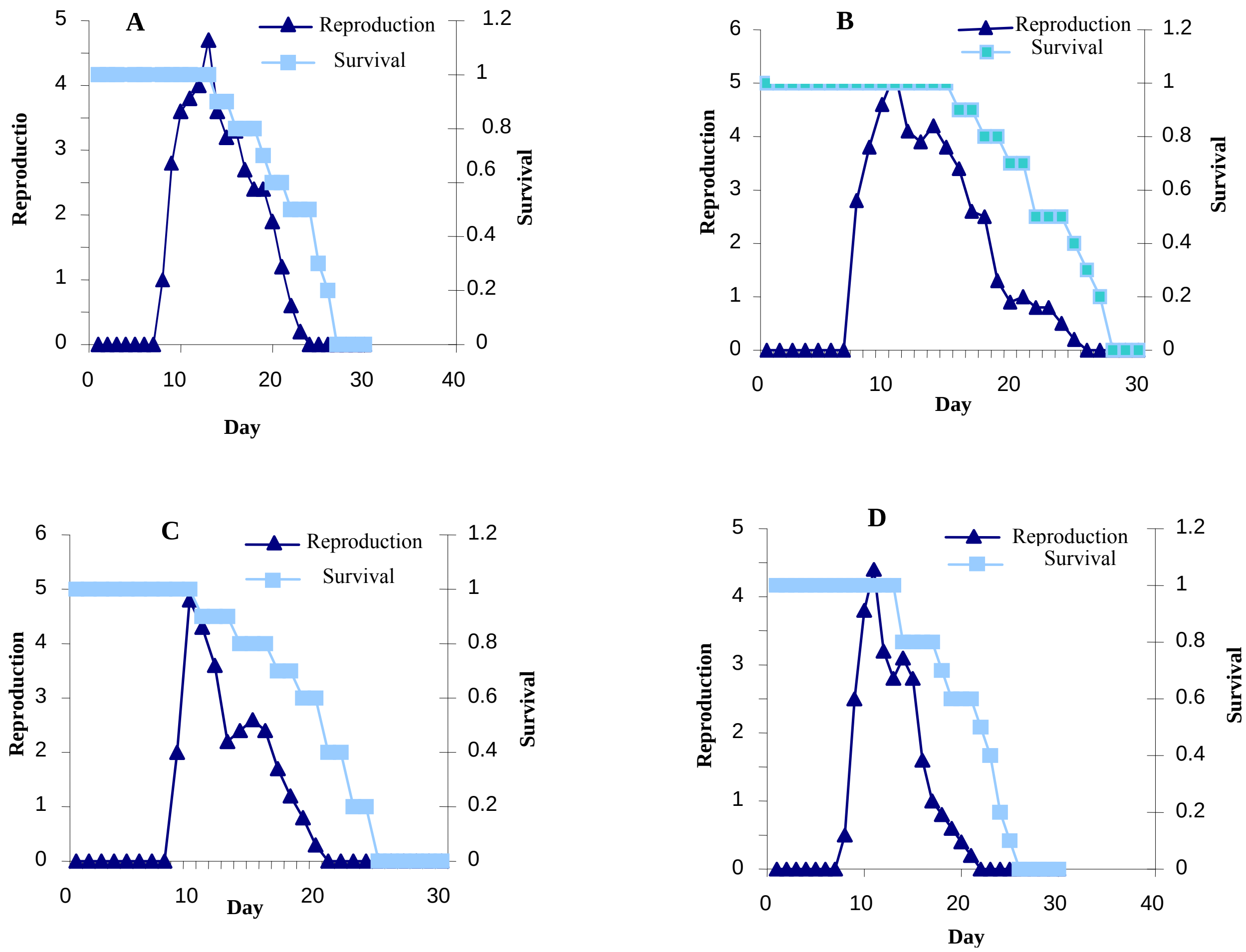
Life table of *B. brassicae* on genotypes

The effect of different host plants on the biology of cabbage aphid was determined by constructing life table for age-specific survival rates (l_x) and fecundity (m_x) per day (Figure 1).

B. brassicae (L.) survived 22.63 to 26.07 days on evaluated genotypes. Obtained results indicated that "Okapi" and "Geronimo" had 23.50 and 48.13 gross reproduction rates, respectively.

The net reproduction rate (R_0) was highest on "Geronimo" (45.46), and lowest on "Okapi" (21.33). Rate of net reproduction in other genotypes was between 24.32 and 37.77.

The intrinsic rate of increase (r_m) was highest (0.274) on "Geronimo", followed by 0.249 on "Modena", 0.246 on "Dexter", 0.227 on "Opera", 0.227 on "Zarfam", 0.221 "Sunday" and 0.2047 on "Okapi" (Table 2).



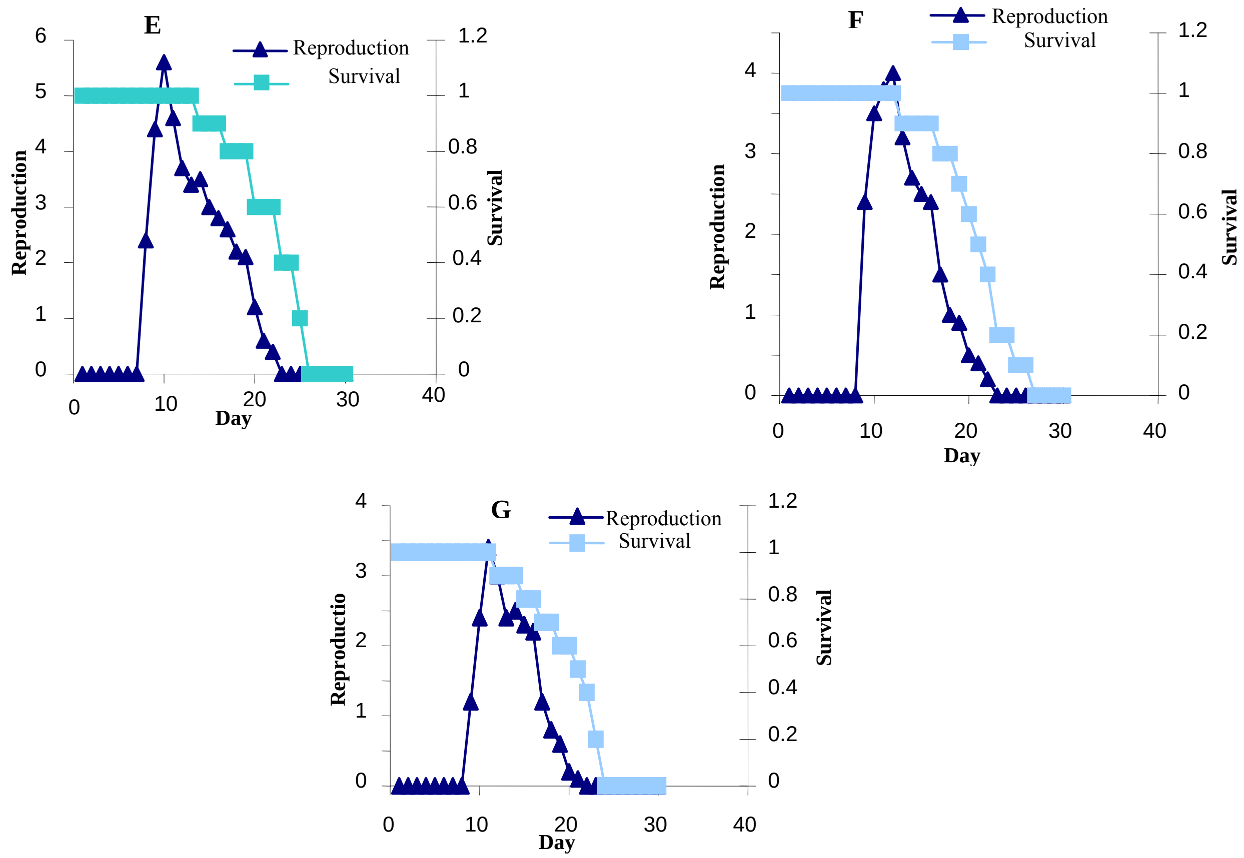


Figure 1. Life tables of *Brevicoryne brassicae* (L.) on seven different canola genotype contain Modena (**A**), Geronimo (**B**), Opera (**C**), Sunday (**D**), Dexter (**E**), Zarfam (**F**) and Okapi (**G**). Line with quadrangle, survival rate (l_x); Line with triangle reproduction (m_x) (nymphs/female/day)

Table 2. Biological parameters of *Brevicoryne brassica* on seven genotype of canola

Genotype	R_0 (Mean ± SE)	r_m (Mean ± SE)	T_0 (Mean ± SE)	DT (Mean ± SE)	λ (Mean ± SE)
Modena	37.77 ± 0.16 b	0.2497 ± 0.0004 b	14.49 ± 0.02 bc	2.777 ± 0.004 d	1.283 ± 0.0005 b
Geronimo	45.46 ± 0.19 a	0.2745 ± 0.0007 a	13.89 ± 0.02 d	2.528 ± 0.007 e	1.316 ± 0.0010 a
Opera	28.22 ± 0.17 d	0.2277 ± 0.0004 c	14.66 ± 0.03 ab	3.046 ± 0.006 c	1.255 ± 0.0005 c
Sunday	24.32 ± 0.42 e	0.2218 ± 0.0006 c	14.34 ± 0.22 c	3.129 ± 0.229 b	1.250 ± 0.0011 c
Dexter	34.20 ± 0.31 c	0.2466 ± 0.0004 b	14.37 ± 0.01 c	2.812 ± 0.005 d	1.279 ± 0.0005 b
Zarfam	27.57 ± 0.36 d	0.2270 ± 0.0004 c	14.60 ± 0.02 abc	3.055 ± 0.005 c	1.254 ± 0.0005 c
Okapi	21.33 ± 0.12 e	0.2047 ± 0.0004 d	14.79 ± 0.02 a	3.389 ± 0.006 a	1.227 ± 0.0005 d

Within columns, means followed by a common letter do not differ significantly (α=0.05, Duncan's multiple range test).

Generation times (T_o) on seven genotypes were between 13.89 days at "Geronimo" and 14.79 days in "Okapi". This parameter shows insect increasing potential and is used to evaluate pests and their natural enemies (Fathi-pour et al., 2005). Therefore "Geronimo" had higher increasing potential for the aphid. Highest and lowest value of doubling time were on "Okapi" (3.39 days) and "Geronimo" (2.53 days), respectively.

The rate of finite growth rate (λ) was (1.316) on "Geronimo", followed by 1.283 on "Modena", 1.279 on "Dexter", 1.255 on "Opera", 1.254 on "Zarfam", 1.250 "Sunday" and 1.227 on "Okapi" (Table 2). Based on low rate of finite growth rate "Okapi" was classified in resistant group and "Geronimo" with highest value of this character was considered as susceptible host plant (Table 2).

According to these results, "Opera" was introduced as resistant genotype between 48 accessions to cabbage aphid (Mohiseni and Torkamani, 2008). *B. brassicae* had also the lowest intrinsic rate of increase on "Okapi" in a greenhouse experiment (Moharrami-pour et al. 2003). The parameters of r_m of aphid calculated according to Wyatt and White (1977) method on genotypes of "Okapi", "Eurol", "PF" and "Boomrang" were 0.239, .0251, 0.265 and 0.29, respectively. In our experiment "Okapi" had highest antibiosis.

DISCUSSION

Resistance of Colza varieties to cabbage aphid varied. Okapi had high level of antibiosis as indicated by low rates of aphid reproduction. Resistance of different varieties of cabbage was explained by biochemical structure of the plant, especially differences in amount of anthocyanins or myrosinase found in cabbage leaves (Ellis et al., 1996; Bridle and Timberlake, 1997). Antibiosis is a special type of resistance, and it has negative effect on the biology parameters of invading insects. Existing of antibiosis decreased size and fecundity of adult insects and increased growth and developmental stages in larva (Jamshidi-Kaljahi et al., 2006). Different levels of antibiosis at cultivars affected reproduction of aphid (Amjad and Peters, 1992).

Intrinsic rate of increase (r_m) depends on the percentage of surviving nymph, developmental time, duration of nymph and fecundity of insect. Therefore this character is an important component of resistance to reflect antibiosis effects and determining degree of resistance (Moharrami-pour et al., 2003). In their experiment Okapi was known resistant genotype with high antibiosis effect on waxy cabbage aphid (Moharrami-pour et al., 2003).

In another experiment "Pf" genotype had high level of antibiosis (Jamshidi-Kaljahi et al., 2006). In their study, maximum reproduction rate of aphid occurred during 9^{th} to 12^{th} days of aphid life. High reproduction of waxy cabbage aphid occurred during the 6^{th} to 9^{th} days of its life and resistance of genotypes varied during developmental stages of accessions (Jamshidi-Kaljahi et al., 2006). "Talayieh" and "Consuol" with intrinsic rate of increase (r_m) (0.2391) and (0.3428) showed high resistance and susceptibility to cabbage aphid, respectively. In a greenhouse experiment "SLMO46" and "Licord" genotypes were classified as medium (Zandi-Sohani et al., 2004). It seems that study about genetic components of resistance is necessary in future investigation and supplementary studies should refer to the chemical, physical and molecular characteristics of host plants.

CONCLUSION

Our results showed that "Okapi" and "Opera" had high antibiotic effect on cabbage waxy aphid and could reduce aphid infestation.

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