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Ten Widely Used Canola Genotypes: A Complex of Highly Resistant and Susceptible Hosts to Feeding *Spodoptera exigua*

Y. Fathipour[1*], M. Pourghasem[1], A. Bagheri[2], and A. A. Talebi[1]

ABSTRACT

The nutritional indices are an important tool in evaluating herbivore responses to variation in host nutritive properties. The current study was conducted to unveil the effects of ten canola cultivars (*Brassica napus* L.) ('Opera', 'Licord', 'Okapi', 'Talaye', 'Zarfam', 'Modena', 'SLM_{046}', 'Sarigol', 'RGS_{003}' and '$Hayula_{420}$') on consumption and utilization indices of the *Spodoptera exigua* (Hübner) larvae. The results revealed significant differences in nutritional indices of different larval instars of *S. exigua* fed on the mentioned canola cultivars. The highest value of Digestion Ability of food (AD) for the third and fourth instars was observed on Licord (86.57% and 83.08%, respectively), and for the fifth instars was on Opera (68.79%). The Relative Growth Rate (RGR) and Relative Consumption Rate (RCR) in the fifth instar larvae were significantly greater on Opera, Okapi and Talaye, whereas the lowest values of Conversion Efficiencies (ECI and ECD) were recorded on these cultivars. The highest ECI was observed in the larvae that consumed RGS_{003} (24.27%), $Hayula_{420}$ (20.36%), and Sarigol (19.17%). Furthermore, the larvae reared on Okapi exhibited the highest RGR, which confirms high susceptibility of this cultivar. Based on the obtained results, Okapi, Talaye and Opera were the cultivars susceptible to *S. exigua*.

Keywords: Beet armyworm, *Brassica napus*, Nutritional indices, Resistant cultivars.

INTRODUCTION

The beet armyworm, *Spodoptera exigua* (Hübner), is a well-known pest in many agricultural areas worldwide, attacking field, vegetable, and flower crops (Mitchell, 1973). It is one of insects known to attack canola and reduce its yield severely (*Brassica napus* L.) (Boyles *et al.*, 2006). Generally, this insect has caused extensive damage to the economic crops, therefore, chemical control is being used to overcome the outbreak. On the other hand, *S. exigua* has developed resistance to many chemical insecticides used against it, necessitating efficient non-chemical approaches (Cobb and Bass, 1975; Brewer and Trumble, 1989; Van Laecke and Degheele, 1991; Mascarenhas *et al.*, 1998; Greenberg *et al.*, 2005). Moreover, most *Bacillus thuringiensis* (Berliner) formulations, used against *Helicoverpa zea* (Hübner), *Trichoplusia ni* (Hübner), *Pieris rapae* L., *Plutella xylostella* (L.), and many other caterpillars, have not been able to suppress *S. exigua* damage (de Maagd *et al.*, 2000), which confirms non-susceptibility of this species and other species of *Spodoptera* to the *Bt* toxins (Moar *et al.*, 1990). In addition, some documents unveil that *S. exigua* has a tolerance behavior in response to Spinosad, an insecticide widely used against this pest (Moulton *et al.*, 2000).

[1] Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, P. O. Box: 14115-336, Tehran, Islamic Republic of Iran.
[*]Corresponding author; e-mail: fathi@modares.ac.ir
[2] Plant Protection Research Department, Hormozgan Agricultural and Natural Resources Research and Education Center, Agricultural Research Education and Extension Organization (AREEO), Bandar Abbas, Islamic Republic of Iran.

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Because of increasing concerns regarding extensive applications of chemical pesticides and development of resistance together with residue problem with usual insecticides, host plant resistance can certainly gain a more important position in management of *S. exigua* and be a main component of an Integrated Pest Management (IPM) system (Kennedy *et al.,* 1987; Fathipour and Sedaratian, 2013). There are promising results regarding resistant plant sources to *S. exigua* in various host plant species, which can be extended by more investigations (Talaee *et al.,* 2017a; b). Resistant varieties present many rewards, such as simplicity of use and low cost for growers, success, and relative safety to humans and the environment. Genetic structure of a host plant affects its defensive attributes against herbivores organisms (Schultz, 1983). By increasing genetic variation, the plant chemical quality may change and enable the plants to show resistance against insect herbivores through affecting insects consumption rate (Meade and Hare, 1993) and performance (Awmack and Leather, 2002; Naseri *et al.,* 2009). Identification of plant resistance mechanisms provides a platform for better understanding the plant-herbivore interactions (Barrett and Agrawal, 2004). The nutritional indices as a proper approach that estimate food consumption, utilization, and growth of insect have been widely used in study of plant-herbivore interactions (Scriber and Slansky, 1981). There are complex relations among nutritional indices (Scriber and Slansky, 1981; Slansky and Scriber, 1985; Fathipour and Mirhosseini, 2017); however, they present a view of nutritional dynamics (Meade and Hare, 1991; Fathipour *et al.*, 2019).

Host plant resistance to *S. exigua* has been examined in tomato (Juvik and Stevens, 1982; Eigenbrode and Trumble, 1993), celery (Griswold and Trumble, 1985; Meade and Hare, 1991; Diawara *et al.,* 1994), chrysanthemum (Yoshida and Parrella, 1992) and soybean (Talekar *et al.,* 1988; Mehrkhou *et al.,* 2012). To date, several experiments have studied the resistance of canola varieties to different insect pests (Aslam *et al.,* 2007; Eickermann and Ulber, 2010; Soufbaf *et al.,* 2010; Fathi, 2011; Karimi *et al.,* 2012; Goodarzi *et al.,* 2015; Fathipour *et al.,* 2018).

The present study was conducted to determine the effect of different canola cultivars on consumption and utilization of *S. exigua*, to unveil the resistant canola cultivars to this pest. The results obtained here can provide insights into implementing better pest management strategies to prevent damage of *S. exigua*.

MATERIALS AND METHODS

Plant and Insect Sources

The ten canola (*B. napus*) cultivars examined were Opera, Licord, Okapi, Talaye, Zarfam, Modena, SLM_{046}, Sarigol, RGS_{003}, and $Hayula_{420}$. The seeds were obtained from the Seed and Plant Improvement Institute (SPII), Karaj, Iran. The seeds were sown in the experimental field of Tarbiat Modares University, Tehran, and no spraying was done on grown plants for rearing *S. exigua* and laboratory studies. The larvae were collected from beet farms of Abyek County in Qazvin Province, Iran. In the laboratory, the larvae were reared for one generation on the same cultivars on which the following generation was evaluated. The insects were maintained at 25±1°C, 60±5% RH, and 16: 8 (L:D) hours photoperiod over the experiment.

Nutritional Indices

Standard gravimetric technique developed by Waldbauer (1968) is the common technique used to calculate food consumption and utilization indices. In order to determine the nutritional indices for the third, fourth and fifth instars, 30 newly hatched larvae in three replicates were set up on each cultivar. The larvae

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were transferred to plastic containers (90×75×40 mm) containing a leaf from each tested cultivar, and located in a growth chamber [25±1°C, 60±5% RH, and 16: 8 (L:D) h]. A fresh leaf was provided every day, if necessary, until the larvae reached to the third instar. The larvae were then weighed and placed individually into containers containing a weighed leaf of the same cultivar upon which they had fed previously. The cut ends of the petioles were wrapped in moist cotton wool to keep leaf fresh. The amount of larval body weight, food ingested and feces produced in each box were daily recorded up to pre-pupation. The nutritional indices were determined just for the larvae that finished the related instars. The pre-pupal and pupal weights were recorded as well.

Dry weights were used to calculate the nutritional indices. Sample individuals from all tested instars feeding on each cultivar and fresh leaves of the same cultivar were weighed, oven-dried at 60°C for 48 hours, and reweighed to obtain conversion factors for the calculation of dry weight of the experimental larvae and food intake. The daily collected feces were also dried under above-mentioned condition. The obtained conversion factors were multiplied by the measured fresh weights in experiment. The nutritional indices using the formulae provided by Cohen (2004) quoted from Waldbauer (1968) were quantified. The indices calculated are shown in Table 1. The mean larval weight during the instar was calculated from addition of initial weight and final weight divided by two.

Statistical Analyses

All data obtained from the nutritional indices were analyzed using One-Way ANOVA (PROC GLM, SAS Institute 2003) and different means were compared statistically at the 5% significance level using the Tukey test.

RESULTS

The results of the analysis of variance for the nutritional indices of the third, fourth and fifth instars of *S. exigua* are presented in Tables 2, 3 and 4.

The nutritional efficiency of the third instar was significantly affected by canola cultivars (Table 2). The larval growth rate varied from 0.53 to 2.13 (mg body mass gained per mg of larval body mass per day) on different canola cultivars. The highest value of this index was related to the larvae reared on Zarfam, while Okapi and Talaye were in the next rank. The lowest larval growth rate was on SLM_{046}.

Likewise the third instar, significant differences were found in nutritional indices of the fourth instars (Table 3). The approximate digestibility of the larvae reared on Sarigol, RGS_{003}, and $Hayula_{420}$ were significantly lower than those reared on the other cultivars. The highest relative growth rate of the fourth instars was observed on Okapi (Table 3).

There were significant differences in consumption rates, efficiency of utilization, and growth rates of the fifth instars of *S. exigua* on various canola cultivars tested (Table 4). The Ability of food Digestion (AD) for the fifth instars ranged from 32.98% on Sarigol to 68.79% on Opera. The AD index, Relative Consumption Rate (RCR), and Relative Growth Rate (RGR) of the insect were significantly higher when the larvae reared on Opera compared with those reared on other cultivars. The larvae reared on Opera exhibited lowest Efficiency of Conversion of Ingested (ECI= 13.97%) and Digested (ECD= 20.32%) food to biomass. Talaye and Okapi, in addition to Opera, showed low conversion efficiencies. The highest ECIs were observed in larvae feeding on RGS_{003} (24.27%), $Hayula_{420}$ (20.36%), and Sarigol (19.17%). Furthermore, the highest ECD of the fifth instars were observed on RGS_{003} (60.14%) and Sarigol (58.95%). The relative growth

Table 1. Nutritional indices for determining consumption and utilization of food by insects (After: Fathipour and Mirhosseini, 2017).

Nutritional index	Equation
Relative Consumption Rate (RCR) or Consumption Index (CI) (Unit: mg mg^{-1} d^{-1})	$\frac{\text{Fresh or dry weight of food eaten (ingested) during feeding period (mg)}(E)}{\text{Mean fresh or dry weight of insect during feeding period (mg)}(A) \times \text{Duration of feeding period (day)}(T)}$ $\frac{E}{A \times T}$
Relative Growth Rate (RGR) (Unit: mg mg^{-1} d^{-1})	$\frac{\text{Fresh or dry weight gain (increase) of insect during feeding period (mg)}(G)}{\text{Mean fresh or dry weight of insect during feeding period (mg)}(A) \times \text{Duration of feeding period (day)}(T)}$ $\frac{G}{A \times T}$
Efficiency of Conversion of Ingested food (ECI) (Unit: Percent)	$\left[\frac{\text{Fresh or dry weight gain (increase) of insect during feeding period (mg)}(G)}{\text{Fresh or dry weight of food eaten (ingested) during feeding period (mg)}(E)}\right] \times 100$ $\left(\frac{G}{E}\right) \times 100$ or $\left(\frac{RGR}{RCR}\right) \times 100$
Efficiency of Conversion of Digested food (ECD) (Unit: Percent)	$\left[\frac{\text{Fresh or dry weight gain (increase) of insect during feeding period (mg)}(G)}{\text{Fresh or dry weight of food eaten (ingested) during feeding period (mg)}(E) - \text{Fresh or dry weight of feces produced during feeding priod (mg)}(F)}\right] \times 100$ $\left(\frac{G}{E-F}\right) \times 100$
Approximate Digestibility (AD) (Unit: Percent)	$\left[\frac{\text{Fresh or dry weight of food eaten (ingested) during feeding period (mg)}(E) - \text{Fresh or dry weight of feces produced during feeding priod (mg)}(F)}{\text{Fresh or dry weight of food eaten (ingested) during feeding period (mg)}(E)}\right] \times 100$ $\left(\frac{E-F}{E}\right) \times 100$

Table 2. Nutritional indices of the third instar larvae of *Spodoptera exigua* on ten canola cultivars. [a]

Cultivar	ECI (%)	ECD (%)	AD (%)	RCR (mg mg^{-1} d^{-1})	RGR (mg mg^{-1} d^{-1})
Opera	7.647±0.278 d	9.736±0.396 cd	78.676±0.583 cd	9.594±0.673 d	0.737±0.062 cd
Licord	4.201±0.380 e	4.877±0.464 e	86.573±1.542 a	19.036±1.101 b	0.789±0.073 c
Okapi	11.412±0.540 bc	16.540±0.750 a	68.955±0.859 e	14.030±0.794 c	1.624±0.132 b
Talaye	4.798±0.418 e	5.705±0.475 e	83.814±1.213 ab	33.610±1.152 a	1.594±0.125 b
Zarfam	6.646±0.318 d	8.154±0.429 d	81.815±1.131 bc	4.341±0.333 f	2.128±0.124 a
Modena	11.804±0.359 b	15.346±0.703 ab	77.579±1.282 d	6.784±0.277 e	0.800±0.037 c
SLM_{046}	7.997±0.439 d	11.345±0.618 c	70.61±1.202 e	6.776±0.495 e	0.532±0.040 d
Sarigol	11.063±0.685 bc	15.970±0.956 ab	69.423±1.518 e	8.193±0.480 de	0.892±0.061 c
RGS_{003}	10.183±0.358 c	14.130±0.577 b	72.327±1.084 e	6.269±0.320 ef	0.643±0.047 cd
$Hayula_{420}$	13.265±0.707 a	17.337±0.961 a	76.753±1.607 d	6.166±0.294 ef	0.826±0.066 c
F	43.29	47.42	24.95	180.26	41.09
df	9, 113	9, 113	9, 113	9, 113	9, 113
P	0.0001	0.0001	0.0001	0.0001	0.0001

[a] Different letters within same columns denote significant differences ($P < 0.05$, Tukey).

Table 3. Nutritional indices of the fourth instar larvae of *Spodoptera exigua* on ten canola cultivars. [a]

Cultivar	ECI (%)	ECD (%)	AD (%)	RCR (mg mg^{-1} d^{-1})	RGR (mg mg^{-1} d^{-1})
Opera	12.688±0.457 e	16.387±0.614 ef	77.477±0.254 b	5.487±0.240 c	0.685±0.012 d
Licord	15.650±0.561 c	18.954±0.864 e	83.083±1.469 a	4.837±0.270 c	0.744±0.025 d
Okapi	13.154±0.454 de	18.878±0.824 e	69.968±0.745 c	12.003±0.591 a	1.569±0.083 a
Talaye	11.480±0.590 e	13.995±0.754 f	82.285±1.163 a	8.182±0.479 b	0.913±0.028 c
Zarfam	14.765±0.485 cd	18.549±0.611 e	79.914±2.089 ab	1.226±0.015 g	1.427±0.040 b
Modena	15.619±0.736 c	23.306±1.174 d	67.34±1.266 cd	3.385±0.190 d	0.526±0.036 e
SLM_{046}	15.695±0.370 c	22.324±0.750 d	70.669±1.028 c	2.113±0.103 f	0.329±0.014 f
Sarigol	19.767±0.359 b	38.002±1.012 b	52.271±1.119 e	2.684±0.179 def	0.528±0.034 e
RGS_{003}	23.495±0.965 a	46.559±1.229 a	50.362±1.268 e	2.439±0.111 ef	0.576±0.037 e
$Hayula_{420}$	18.729±0.914 b	28.990±1.173 c	64.614±1.663 d	3.075±0.249 de	0.564±0.039 e
F	33.7	122.24	79.24	129.69	109.59
df	9, 113	9, 113	9, 113	9, 113	9, 113
P	0.0001	0.0001	0.0001	0.0001	0.0001

[a] Different letters within same columns denote significant differences ($P < 0.05$, Tukey).

Table 4. Nutritional indices of the fifth instar larvae of *Spodoptera exigua* on ten canola cultivars. [a]

Cultivar	ECI (%)	ECD (%)	AD (%)	RCR (mg mg^{-1} d^{-1})	RGR (mg mg^{-1} d^{-1})
Opera	13.965±0.335 d	20.317±0.473 f	68.790±0.932 a	2.843±0.067 a	0.398±0.016 a
Licord	16.143±0.400 c	45.261±0.594 c	35.758±1.092 gh	2.199±0.143 c	0.353±0.023 b
Okapi	14.587±0.474 d	26.384±0.911 e	55.502±1.317 c	2.466±0.103 b	0.356±0.011 ab
Talaye	13.252±0.489 d	22.271±1.097 f	60.126±1.815 b	2.526±0.123 b	0.332±0.016 b
Zarfam	16.766±0.417 c	37.449±1.066 d	44.901±0.858 d	1.200±0.030 ef	0.200±0.005 e
Modena	16.928±0.320 c	45.603±1.373 c	37.403±0.964 fg	1.677±0.071 d	0.283±0.012 c
SLM_{046}	16.530±0.350 c	50.218±1.288 b	33.151±0.988 h	1.329±0.080 ef	0.218±0.013 de
Sarigol	19.174±0.396 b	58.949±2.253 a	32.98±1.292 h	1.755±0.105 d	0.336±0.020 b
RGS_{003}	24.272±0.704 a	60.137±1.719 a	40.637±1.426 ef	1.068±0.064 f	0.258±0.014 cd
$Hayula_{420}$	20.361±0.550 b	47.109±1.238 bc	43.468±1.439 de	1.357±0.080 e	0.274±0.015 c
F	52.31	119.61	98.37	46.49	17.99
df	9, 113	9, 113	9, 113	9, 113	9, 113
P	0.0001	0.0001	0.0001	0.0001	0.0001

[a] Different letters within same columns denote significant differences (P< 0.05, Tukey).

rate of the fifth instars was in the range of 0.2-0.4 (mg mg^{-1} d^{-1}) on canola cultivars examined. Different cultivars exhibited significant effects on the pre-pupal and pupal weights (Table 5). The heaviest pupae were related to the larvae that consumed Opera.

DISCUSSION

Resistance level of host plants to insect herbivores can be evaluated by comparing the nutritional indices of the insects on different cultivars. In the current study, we obtained interesting results regarding nutritional indices of *S. exigua* on different canola cultivars, resulting in a clear-cut grouping of the cultivars. The results obtained from comparing nutritional indices of *S. exigua* exhibited significant differences in the ECI and ECD on different canola cultivars. This returns to variation in the nutritional quality of these cultivars. The ECI is an index that shows insect's ability to utilize the food for growth. The ECD reflects the nutritional value of cultivars after disposal of non-digestible material. Among the canola cultivars tested, the highest values of ECI were observed on RGS_{003}, $Hayula_{420}$, and Sarigol, representing a more efficient conversion of food into larval body mass on these cultivars. In contrast, Talaye, Opera, and Okapi allocated the lowest values of ECI and ECD, indicating the low nutritional value of these cultivars for the beet armyworm larvae. Broadway and Duffy (1986) argued that allelochemicals produce a reduction in food conversion efficiency indirectly through limiting the biological availability of nutrients and ultimately affect the performance of an insect herbivore. Low ECD values are usually accompanied with high AD values (Slansky and Scriber, 1985; Soleimannejad *et al.*, 2010). Increased value of AD on Opera, Talaye, and Okapi might be due to compensating the lower value of ECI and ECD on these host plants. Bauce *et al.* (1994) confirmed that the foods with high digestibility cause low conversion efficiency in no-choice nutritional conditions.

Among canola cultivars, the highest value of RCR for the last instar of *S. exigua* larvae was estimated on Opera, Okapi, and Talaye. In response to differences in host qualification causing a reduction in conversion efficiencies, the herbivores show a compensatory feeding behavior (Lavoie and Oberhauser, 2004). This is due to homeostatic adjustment of these parameters

Table 5. Mean pre-pupal and pupal weight of *Spodoptera exigua* on ten canola cultivars. [a]

Cultivar	Pre-pupal weight (mg)	Pupal weight (mg)
Opera	34±1.21 ab	34.97±0.97 a
Licord	31.13±1.61 bc	27.08±1.09 b
Okapi	36.45±2.14 a	27.93±0.90 b
Talaye	33.77±1.02 abc	29.69±0.89 b
Zarfam	28.93±1.22 c	27.14±1.05 b
Modena	35.72±1.69 ab	29.80±1.40 b
SLM_{046}	31.50±1.10 abc	29.27±1.13 b
Sarigol	33.35±1.43 abc	28.84±1.13 b
RGS_{003}	32.30±1.84 abc	29.00±1.67 b
$Hayula_{420}$	33.62±1.65 abc	26.46±1.44 b
F	2.12	3.91
df	9, 113	9, 113
P	0.0333	0.0002

[a] Different letters within *same* columns denote significant differences (P< 0.05, Tukey).

(relative consumption rate and conversion efficiencies), so that, even in different food quality conditions, an insect can achieve its best growth rate (Lindroth, 1993). Foliage of Opera, Talaye, and Okapi are poor in nutritive quality and fed in larger masses.

In parallel with the current study, regarding low nutritive quality of some cultivars resulting in more feeding behavior to compensate the nutritive deficiency, Fathipour *et al.* (2018) found the same results with *Helicoverpa armigera* (Hübner). They obtained the lowest values of ECI and ECD of the last instar on Okapi (6.1 and 7.4%, respectively) and the highest value of RCR on the same cultivar. Therein, likewise *S. exigua*, *H. armigera* reared on Okapi could offset less efficient conversion to biomass by increasing consumption rates more than those of larvae reared on other cultivars.

The larvae feeding on Opera and Okapi had the high RGR, particularly in the last instar, showing high suitability of these cultivars in supplying *S. exigua* larvae to have better growth rate compared with the other cultivars. Suitability of Okapi as a proper host of *S. exigua* has been shown by Goodarzi *et al.* (2015) as well. Effects of the plant cultivars on larval growth rate can result in changes in consumption rate and approximate digestibility and conversion efficiencies (Lindroth and Peterson, 1988). High growth rate on Opera and Okapi is due to enhanced digestibility of the primary metabolites existing in these cultivars and lacking or low amounts of secondary metabolites (Woods, 1999). Although leaves nitrogen is a main factor in growth rate of herbivores (Scriber, 1984; Zalucki *et al.*, 2002), studies on *S. exigua* larvae have shown that there are no tendency toward high nitrogen accumulation in foliage of some celery cultivars (*Apium graveolens* L.) (Griswold and Trumble, 1985; Meade and Hare, 1991). Lower conversion efficiency due to lower nitrogen content could be compensated by more consumption (Meade and Hare, 1991), which can be also true for our experiment. Besides, this is supported by Yoshida and Parella (1992) who concluded that some factors apart from nitrogen might affect the nutritional ecology of *S. exigua* on chrysanthemum cultivars.

It is true for insects that the host nutritional value ranks in the first importance, but allelochemicals effects on the biology and feeding behavior of herbivore could have the same importance in insect performance (Scriber and Slansky, 1981). Regarding conversion efficiencies on other cultivars (except Okapi, Talaye, and Opera), it seems that they are rich in nutritional quality, but due to high amounts of secondary metabolites in these cultivars, the larvae may not succeed to digest enough food intake and suffer from feeding on these cultivars (Fathipour and Mirhosseini, 2017). This cost results in less consumption and, ultimately, low growth rate of herbivore. On celery, RGR in final instar of *S. exigua* ranged from 0.24 to 0.57 (mg mg^{-1} d^{-1}), depending on cultivar (Meade and Hare, 1991). This is slightly higher than what was obtained on canola cultivars (0.20 to 0.40).

The fifth instars of *S. exigua* were feeding less on the canola cultivars (with regard to body weight) than the fourth and third instars. In other words, the younger larvae obtained higher relative consumption rate compared to the older ones. Furthermore, the relative growth rate and assimilation efficiency in the younger larvae were greater than the older larvae, whereas conversion efficiencies were reduced from early to late instars. These results are in agreement with Scriber and Slansky (1981) who noted that trend of relative consumption rate, growth rate, and digestibility generally decreased during larval stage, while conversion efficiencies increased.

Allelochemicals variations in different plant cultivars cause differences in plant resistance to herbivores. The present study, most likely consistent with other literatures (Griswold and Trumble, 1985; Meade and Hare, 1991; Yoshida and Parella, 1992), indicated that, in contrast to the general conception for insects, the larvae of *S. exigua* show better growth on less efficient host plant. Further works will be needed to measure nitrogen content of canola cultivars to clarify if differences in nutritional efficiencies of *S. exigua* larvae are due to nutrient content or allelochemicals effects.

Some of the canola cultivars, known as susceptible hosts in the current study, have also shown susceptibility in facing with other insect pests. For instance, the Opera, as a susceptible cultivar to *S. exigua*, has shown high susceptibility to *Brevicoryne brassicae* (L.) (Karami *et al.*, 2018); *P. xylostella* (Soufbaf *et al.*, 2010; Nikooei *et al.*, 2015) and *H. armigera* (Karimi *et al.*, 2012). This information confirms high susceptibility of this cultivar and necessitates its replacement by other resistant cultivars. By contrast, there were some cultivars like Okapi, RGS_{003}, and SLM_{046} that performed different responses in facing with various pests. While RGS_{003} was a susceptible cultivar against *P. xylostella* (Nikooei *et al.*, 2015), it showed high resistance to *B. brassicae* (Karami *et al.*, 2018). It was also true for Okapi and SLM_{046}. Okapi was susceptible to *S. exigua* (present study) and SLM_{046} was susceptible to *P. xylostella* (Fathipour *et al.*, 2019), whereas elsewhere, Okapi and SLM_{046} showed resistance to *B. brassicae* (Karami *et al.*, 2018) and *H. armigera* (Karimi *et al.*, 2012), respectively. However, in a successful integrated pest management program, attention to the type of prevalent and destructive insect pest in each region is necessary. In the case of these cultivars, their possible consideration in an integrated pest management program can be based on the existence of the pest species.

Moreover, in study of pest-resistance potential of the crop germplasm, one of the most important factors is extension of the resistance to different prevalent pest species. A host plant with broad-spectrum resistance to different pests can be an appropriate candidate for exploitation in the integrated pest management programs. As mentioned above, the studied canola cultivars have been included in experiments of other researchers. A converging point in all of these studies has been expressed by similarity in the obtained results in all cases: some cultivars like Licord, Zarfam, Modena, and Sarigol showed high level of resistance and other cultivars with a little difference showed a susceptible response against different pests. However, in some cases, there was a discrepancy in results of the above-mentioned studies, particularly among susceptible cultivars. Apart from some differences mentioned here, with respect to intra-population variation of pest species, these findings can be valuable because they reflect high potential of these host plants to tolerate different pests without any significant losses in their yield. This rate of damage can be mitigated by other non-chemical approaches.

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شناسایی ارقام بسیار حساس و مقاوم به کرم برگخوار چغندر قند *Spodoptera exigua* در بررسی ده ژنوتیپ بسیار متداول کلزا

ی. فتحی پور، م. پور قاسم، ع. باقری، و ع. ا. طالبی

چکیده

بررسی شاخص‌های تغذیه‌ای یک روش ارزشمند برای ارزیابی واکنش حشرات گیاهخوار نسبت به تغییر در ویژگی‌های غذایی گیاهان میزبان آنها است. پژوهش حاضر با هدف بررسی اثر ده رقم کلزا (*Brassica napus* L.) شامل 'Opera'، 'Licord'، Okapi'، 'Talaye'، 'Zarfam'، 'Modena'، 'SLM$_{046}$'، 'Sarigol'، 'RGS$_{003}$' و 'Hayula$_{420}$' روی شاخص‌های تغذیه‌ای کرم برگخوار چغندر قند *Spodoptera exigua* انجام شد. نتایج نشان داد که اختلافات معنی داری در شاخص‌های تغذیه‌ای سنین مختلف لاروی کرم برگخوار چغندر قند روی ارقام مورد مطالعه وجود دارد. بیشترین مقدار شاخص تقریبی هضم شوندگی (AD) برای لاروهای سنین سوم و چهارم (به ترتیب ۸۶/۵۷ و ۸۳/۰۸ درصد) روی رقم Licord و برای لاروهای سن پنجم (۶۸/۷۹ درصد) روی رقم Opera مشاهده شد. نرخ رشد نسبی (RGR) و نرخ مصرف نسبی (RCR) در لاروهای سن پنجم به طور معنی داری روی رقم Opera، Okapi و Talaye بیشتر بود. کمترین مقدار کارایی تبدیل غذای خورده شده (ECI) و کارایی تبدیل غذای هضم شده (ECD) روی Opera، Okapi و Talaye بود. بیشترین مقدار ECI در لاروهایی مشاهده شد که روی RGS$_{003}$ (۲۴/۳ درصد)، Hayula$_{420}$ (۲۰/۴ درصد) و Sarigol (۱۹/۲ درصد) تغذیه کردند. به علاوه، لاروهایی که روی Okapi تغذیه کردند دارای بیشترین RGR بودند که تاییدی بر حساسیت بالای این رقم بود. با توجه به نتایج به دست آمده ارقام Okapi، Talaye و Opera ارقام حساس به تغذیه *S. exigua* بودند.