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RESEARCH REPORT

Effect of geographic origin of *Spodoptera exigua* (Lepidoptera: Noctuidae) and sugar beet cultivar on nutritional indices of this pest

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Abstract

Nutritional indices of three geographic populations (Miandoab, Moghan and Kalposh) of the fifth instar of *Spodoptera exigua* (Lepidoptera: Noctuidae) on four sugar beet cultivars (Dorothea, Rozier, Persia and Perimer) were evaluated at 25 ± 1 °C, 65 ± 5 % RH and a 16:8 L:D photoperiod. The estimates of all the nutritional indices were affected by the interaction effect of the geographic population and the sugar beet cultivars. Miandoab population reared on Dorothea, and Moghan and Kalposh populations reared on Perimer had the highest approximate digestibility (AD). Miandoab and Kalposh populations reared on Rozier showed the highest efficiency of conversion of ingested food (ECI) and efficiency of conversion of digested food (ECD) values. Moghan population reared on Persia showed the lowest AD values and the highest ECI and ECD values. The present study showed that the nutritional indices of three populations, in most cases, were significantly different from with other, due to different environmental conditions that the pest collected from there. It is concluded that both geographic origins of the pest and host cultivar affected the nutritional indices of *S. exigua* larvae.

Key Words: beet armyworm; feeding performance; geographic population; host cultivar

Introduction

Sugar beet (*Beta vulgaris*) is a root crop commonly used for sugar production and is an important food source (Biancardi *et al.,* 2012). Iran is one of 50 countries in the world that produces sugar beet in large scales (Yazdani and Rahimi, 2012). The beet armyworm, *Spodoptera exigua* (Lepidoptera: Noctuidae), is a polyphagous species, which feeds on more than 90 plant species of over 18 plant families (Mehrkhou *et al.,* 2012). It is a migratory species, originating from South Asia, and occurs at latitudes between 35° to 40°S and 40° to 57°N in tropical, subtropical and temperate regions (Zhang and Zhao, 1996). This pest causes economic damages to sugar beet, corn and alfalfa in Iran (Farahani *et al.,* 2011; Mehrkhou, 2013; Goodarzi *et al.,* 2015).

High migratory capacity of this insect facilitates the geographic dispersal of populations beyond its normal distribution range, and causes outbreak of its populations (Kimura 1991; Burris *et al.,* 1994; Adamczyk *et al.,* 2003). Management of *S. exigua* is difficult due to high migratory dispersal and rapid resistance development to pesticides (Adamczyk *et al.,* 2003; Shimada *et al.,* 2005). Host plant quality could affect population dynamics of herbivorous insects by influencing their spatial distribution and the migration rates (Howard and Dixon, 1992).

There are evidences documented that plants nutritional status can influence their susceptibility to several herbivores (Mattson, 1980). Minerals are one of the main nutritional requirements of insects among amino acids, vitamins, carbohydrates, lipids and sterols (Dadd, 1985). Insects require elements such as potassium, phosphorus and magnesium considerably higher than calcium, sodium (Na) and chlorides during their development (Dale, 1988). Effect of mineral concentration of host plants on herbivorous insects that feed on them could be positive, neutral or negative (Dale, 1988). Nitrogen (N) affects life history of insects such as growth (Kainulainen *et al.,* 1996), survival (Ayres *et al.,* 2000) and reproduction (Bentz and Townsend, 2001), because it plays an important role in the production of amino acid and synthesis of protein (Sterner and Elser, 2002). Generally, concentration of nitrogen in plant leaf is an indicator of food quality affecting host plant selection by polyphagous insects. Phosphorus (P) is another nutritional element in plant tissues that could affect

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survivorship (Ayres *et al.,* 2000), fecundity (Popp *et al.,* 1989), body size (Busch and Phelan, 1999), oviposition (Skinner and Cohen, 1994), growth rate (Perkins *et al.,* 2004) and population density of insects (Schade *et al.,* 2003). The enzyme cofactor potassium (K) (Mengel *et al.,* 2001) is an important element in host plant quality (Leigh and Wyn Jones, 1984) and in the process of amino acids conversion into proteins.

There are several studies regarding the biological parameters of *S. exigua* on different host plants such as cotton, pepper, pigweed and sunflower (Greenberg *et al.,* 2001), shallot, long bean, lady's finger and chilli (Azidah and Sofian-Azirun, 2006), wheat, cabbage and pea (Saeed *et al.,* 2010), corn (Mardani-Talaei *et al.,* 2012), soybean varieties (Farahani *et al.,* 2011; Mehrkhou *et al.,* 2012; Mehrkhou, 2013) and beet varieties (Karimi-Malati *et al.,* 2014). However, despite the importance of sugar beet as a rotational crop, and high economic damages caused by different populations of *S. exigua* to this crop (Saghfi and Valizadegan, 2014), no published papers are available on the nutritional indices of different geographic populations of *S. exigua* on sugar beet cultivars. Therefore, the aim of this research was to study the effect of host plant cultivar and geographic origin of the pest on the nutritional indices of *S. exigua*. To understanding this, four commercial sugar beet cultivars and three geographic populations of *S. exigua* were used. Despite using the same laboratory conditions for rearing of all the populations, observation of variations in nutritional responses of *S. exigua* that were collected from different geographic regions was expected. Moreover, the concentration of some important minerals (N, P, K and Na) in the leaves of the four tested sugar beet cultivars was measured and their relationship with food consumption and utilization by *S. exigua* was studied.

Materials and Methods

Plant sources

Seeds of four different sugar beet (*B. vulgaris*) cultivars, including Dorothea, Rozier, Persia and Perimer were acquired from the Plant and Seed Modification Research Institute of Sugar Beet (Ardabil, Iran). They were grown in the research field of the University of Mohaghegh Ardabili (Ardabil, Iran) in May 2014. Selection of these cultivars was based on their importance as the most cultivated sugar beets in different regions of Iran. For this study, the young leaves (with equal size) of various sugar beet cultivars at four leaf stage were transferred to a growth chamber at 25 ± 1 °C, 65 ± 5 % RH, with a 16:8 L:D photoperiod and used for the experiment.

Insect rearing

Larval colonies (fifth instar) of *S. exigua* were collected from three regions of Iran that have the highest production of sugar beet. These regions included Semnan (Kalposh), Western Azarbayjan (Miandoab) and Ardabil (Moghan). The main sugar beet cultivars planted in Miandoab, Moghan and Kalposh regions were Dorothea, Rozier and Perimer, respectively. Kalposh population was collected from cultivar Perimer, and Miandoab and Moghan populations were collected from cultivars Dorothea and Rozier, respectively. To eliminate the effect of prior feeding experience on local host plant and provide the same cultural conditions for three populations, larval population from each region was reared separately, for two generations, on another sugar beet cultivar (Torbat).

Nutritional indices experiments

Nutritional indices (including weight gain, food consumption and feces produced by the larvae) were calculated gravimetrically (Waldbauer, 1968). In this study, nutritional indices of fifth instar larvae were calculated because they were more measurable than the younger instars. For this purpose, 30 fifth instar larvae of *S. exigua* from each population were individually transferred into plastic containers (diameter 16.5 cm, depth 7.5 cm) with outlets covered by a mesh net for larval aeration. The fresh leaves of the tested sugar beet cultivars for each population were placed in each container. The petioles of the detached leaves were inserted in a water-soaked cotton to keep freshness. For pupal stage, pre-pupae were transferred into small plastic tubes (diameter 2 cm, depth 5 cm). The weights of the larvae were recorded daily before and after feeding until they finished feeding and reached pre-pupal stage. The provided fresh leaves and the remaining leaves and feces at the end of each experiment were weighed daily. The amount of leaf consumption per larva was calculated by subtracting the weight of remaining leaf from the weight of fresh leaf supplied at the end of each experiment. All the above-mentioned weights were recorded as percentage of dry weights. To calculate the dry weight of leaf, larvae and feces, 20 specimens of newly molted larvae and 20 specimens of the remaining leaves and feces produced were collected, weighed and dried at 60 °C for 48 h, then reweighed. Nutritional indices were calculated via formulae described by Waldbauer (1968): approximate digestibility (AD) = E-F/E; efficiency of conversion of ingested food (ECI) = P/E; efficiency of conversion of digested food (ECD) = P/E-F; relative consumption rate (RCR) = E/A*T; and relative growth rate (RGR) = P/A*T. Where, A = mean dry weight of insect over unit time, E = dry weight of food consumed, F = dry weight of feces produced, P = dry weight gain of insect, and T = duration of feeding period (days).

Determination of minerals in sugar beet cultivars

Leaf samples of four tested sugar beet cultivars were oven dried (at 60 °C) for 48 h, and then ground with electric mills. For determination of phosphorus, potassium and sodium, approximately 0.2 g of dried powdered leaves were digested by sulfuric acid, salicylic acid and H_2O_2. After digestion, phosphorus concentration was measured spectrophotometrically and absorbance was read at 470 nm using colorimetry method (Waling *et al.,* 1989). Sodium and potassium concentrations were estimated flame photometerically (Waling *et al.,* 1989). Nitrogen concentration was determined by Kjeltec Auto 1030 Analyzer (Emami, 1996).

Data analysis

Nutritional indices of *S. exigua* were conducted using factorial design with two main factors (population in three levels and cultivar in four levels). The data were analyzed with two-way ANOVA using SAS program (SAS Institue, 1989) followed by comparison of the means with LSD test at $\alpha = 0.05$. Data for mineral concentrations were analyzed with one-way ANOVA using SAS program (SAS Institue, 1989) and mean comparison was done with LSD test at $\alpha = 0.05$. Before analysis, all the data were tested for normality by Kolmogorov-Smirnov method which were normally distributed.

Results

Nutritional indices of *S. exigua* were studied in three geographic populations of this pest in response to feeding on four sugar beet cultivars. In this study, by using factorial design, both effects of population, sugar beet cultivar and their interaction on nutritional indices of *S. exigua* (Table 1) were studied. The statistics in Table 1 show that the effect of population, cultivar and population×cultivar for all the nutritional indices of *S. exigua* had significant difference at α = 0.01.

Effect of population and sugar beet cultivar on AD value of S. exigua

The effect of population and sugar beet cultivar on AD value of the fifth instar of *S. exigua* is given in Table 2. Kalposh population reared on cultivars Dorothea (F = 5.22; df = 2.80; p = < 0.01), Rozier (F = 33.60; df = 2.87; p < 0.01), Persia (F = 15.34; df = 2.85; p < 0.01) and Perimer (F = 36.63; df = 2.80; p < 0.01) showed the highest AD values as compared to the Miandoab and Moghan populations. Among different sugar beet cultivars, within populations, the highest AD value was observed in cultivar Perimer in Moghan (F = 27.69; df = 3.114; p < 0.01) and Kalposh (F = 36.97; df = 3.111; p < 0.01) populations, and cultivar Dorothea in Miandoab (F = 16.39; df = 3.107; p < 0.01) population. The lowest AD value was observed in cultivar Persia in Kalposh and Moghan populations and cultivar Rozier in Miandoab population.

Effect of population and sugar beet cultivar on ECI value of S. exigua

The effect of population and sugar beet cultivar on ECI value of the fifth instar of *S. exigua* is shown in Table 2. Among the three populations reared on the four sugar beet cultivars, Miandoab population reared on cultivars Dorothea (F = 5.61; df = 2.85; p < 0.01) and Rozier (F = 34.32; df = 2.92; p < 0.01), and Kalposh population reared on cultivar Perimer (F = 31.16; df = 2.78; p < 0.01) showed higher ECI values. Miandoab and Moghan populations reared on cultivar Persia (F = 4.20; df = 2.89; p < 0.01) showed higher ECI values than Kalposh population. Within populations reared on different sugar beet cultivars, Miandoab (F = 80.36; df = 3.113; p < 0.01) and Kalposh (F = 28.18; df = 3.111, p < 0.01) populations reared on cultivar Rozier and Moghan population (F = 40.14; df = 3.120; p < 0.01) fed on Persia showed the highest ECI values compared to the other cultivars.

Table 1 Summary results of ANOVA for the effect of population, sugar beet cultivar and their interaction on nutritional indices of fifth instar of *Spodoptera exigua*

Index	Source of variation	df	F
AD	Population	2	37.92
(%)	Cultivar	3	45.97
	Population×Cultivar	6	10.08
	Error	336	
ECI	Population	2	26.31
(%)	Cultivar	3	128.00
	Population×Cultivar	6	17.40
	Error	336	
ECD	Population	2	22.26
(%)	Cultivar	3	84.60
	Population×Cultivar	6	13.22
	Error	336	
RCR	Population	2	14.46
(mg/mg/day)	Cultivar	3	198.47
	Population×Cultivar	6	53.60
	Error	336	
RGR	Population	2	14.10
(mg/mg/day)	Cultivar	3	6.10
	Population×Cultivar	6	10.32
	Error	336	

AD = approximate digestibility, ECI = efficiency of conversion of ingested food, ECD = efficiency of conversion of digested food, RCR = relative consumption rate, RGR = relative growth rate. (ANOVA, $p < 0.01$)

Table 2 Effect of geographic origin of *Spodoptera exigua* and sugar beet cultivar on nutritional indices (mean±SE) of fifth instar of this pest

Cultivar	Miandoab population	Moghan population	Kalposh population
		AD (%)	
Dorothea	85.41±1.27 a, B	84.52±0.99 a, B	88.95±0.95 b, A
Rozier	70.56±2.51 b, C	81.81±2.34 a, B	93.77±0.50 a, A
Persia	71.47±2.32 b, B	56.46±4.91 b, C	81.51±1.28 c, A
Perimer	83.79±0.92 a, C	89.63±0.60 a, B	93.83±0.92 a, A
		ECI (%)	
Dorothea	4.56±0.25 b, A	3.29±0.22 b, B	4.00±0.30 c, AB
Rozier	21.70±1.39 a, A	10.14±0.80 a, B	12.58±0.79 a, B
Persia	12.61±1.01 a, A	11.97±1.13 a, A	8.72±0.83 b, B
Perimer	4.95±0.21 b, B	2.48±0.20 b, C	6.79±0.66 b, A
		ECD (%)	
Dorothea	5.53±0.35 c, A	3.93±0.29 c, B	4.55±0.36 c, B
Rozier	30.88±2.28 a, A	12.61±1.11 b, B	16.65±1.93 a, B
Persia	19.90±1.91 b, A	22.95±3.47 a, A	10.51±1.16 b, B
Perimer	5.93±0.26 c, B	2.79±0.23 c, C	7.35±0.78f bc, A
		RCR (mg/mg/day)	
Dorothea	5.58±0.32 a, B	10.29±0.49 a, A	6.32±0.31 b, B
Rozier	1.63±0.15 c, B	2.03±0.18f b, AB	2.47±0.15 c, A
Persia	2.91±0.23 b, A	2.03±0.18f b, B	2.07±0.14 c, B
Perimer	5.46±0.21 a, B	2.56±0.24 b, C	9.26±0.48 a, A
		RGR (mg/mg/day)	
Dorothea	0.24±0.01 c, B	0.32±0.01 a, A	0.26±0.01 a, B
Rozier	0.29±0.02 b, A	0.20±0.01 bc, B	0.29±0.01 a, A
Persia	0.37±0.01 a, A	0.23±0.02 b, B	0.18±0.01 b, C
Perimer	0.27±0.01 bc, A	0.16±0.01 c, C	0.21±0.01 b, B

The means followed by different small letters in the same column for each population and different capital letters in the same row for each cultivar are significantly different (LSD, $p < 0.01$)

Effect of population and sugar beet cultivar on ECD value of S. exigua

Table 2 shows the effect of population and sugar beet cultivar on ECD value of the fifth instar of *S. exigua*. Among the three populations reared on the tested cultivars, the ECD value of larvae collected from Kalposh on cultivar Perimer (F = 26.30; df = 2.78; $p < 0.01$) was higher than that of the other populations. However, Miandoab population reared on cultivars Dorothea (F = 5.56; df = 2.85; $p < 0.01$), Rozier (F = 29.14; df = 2.88; $p < 0.01$) and Moghan population reared on cultivar Persia (F = 7.99; df = 2.89; $p < 0.01$) showed the highest ECD value when compared with any other population. Among the different sugar beet cultivars, the highest ECD values on Miandoab (F = 54.93; df = 3.122; $p < 0.01$) and Kalposh (F = 19.54; df = 3. 105; $p < 0.01$) populations were observed on cultivar Rozier and the lowest values were seen in cultivar Dorothea. Moghan (F = 29.08; df = 3.113; $p < 0.01$) population reared on cultivars Persia and Perimer showed the highest and lowest ECD values, respectively for larval population collected from this region.

Effect of population and sugar beet cultivar on RCR value of S. exigua

The effect of population and sugar beet cultivar on RCR of fifth instar of *S. exigua* is shown in Table 2. Among the three populations reared on cultivars

Table 3 The mean (±SE) nitrogen, phosphorus, potassium and sodium contents in the leaves of four tested sugar beet cultivars used for feeding of *Spodoptera exigua* larvae

Cultivar	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Sodium (%)
Dorothea	3.665±0.083 a	0.538±0.020 a	5.145±0.188 a	6.190±0.352 a*
Rozier	3.426±0.067 a	0.377±0.018 bc	3.590±0.159 b	4.783±0.162 b
Persia	3.463±0.114 a	0.292±0.004 c	4.090±0.221 b	3.763±0.324 b
Perimer	3.523±0.143 a	0.412±0.063 b	5.310±0.115 a	4.293±0.557 b

The means followed by different letters in the same column are significantly different (LSD, $p < 0.01$, $^{*}p < 0.05$)

Rozier (F = 6.47; df = 2.86; $p < 0.01$) and Perimer (F = 6.70; df = 2.81; $p < 0.01$), Kalposh showed higher RCR values as compared to the other populations, whereas, Moghan population reared on cultivar Dorothea (F = 42.62; df = 2.84; $p < 0.01$), and Miandoab population reared on cultivar Persia (F = 96.39; df = 2.76; $p < 0.01$), showed higher RCR value than the others. Within populations, cultivar Dorothea showed the highest RCR value and cultivar Rozier showed the lowest RCR value for Miandoab (F = 65.03; df = 3.111; $p < 0.01$) population. Cultivar Dorothea in Moghan (F = 173.89; df = 3.108; $p < 0.01$) population showed higher RCR value than other cultivars. Kalposh (F = 125.80; df = 3.108; $p < 0.01$) population reared on cultivar Perimer showed the highest RCR value and cultivar Persia showed the lowest RCR value.

Effect of population and sugar beet cultivar on RGR value of S. exigua

The effect of population and sugar beet cultivar on RGR of fifth instar of *S. exigua* is shown in Table 2. Moghan population reared on cultivar Dorothea (F = 6.42; df = 2.76; $p < 0.01$), Miandoab and Kalposh populations reared and cultivar Rozier (F = 9.73; df = 2.89; $p < 0.01$) and Miandoab population reared on cultivars Persia (F = 29.65; df = 2.86; $p < 0.01$) and Perimer (F = 13.16; df = 2.78; $p < 0.01$) showed the highest RGR values. Within populations, Mindoab (F = 10.71; df = 3.114; $p < 0.01$) reared on cultivar Persia, Kalposh (F = 12.31; df = 3,108; $p < 0.01$) reared on cultivar Rozier and Moghan (F=11.74; df = 3.107; $p < 0.01$) population reared on cultivar Dorothea showed the highest RGR values. Cultivar Dorothea in Miandoab population, cultivar Perimer in Moghan population and cultivar Persia in Kalposh population showed the lowest RGR values.

Determination of minerals in the different sugar beet cultivars

Table 3 shows the minerals content of the leaf of the four tested sugar beet cultivars. No significant difference was observed for nitrogen content (F = 1.25; df = 3.8; $p = 0.356$) in the different sugar beet cultivars. However, the highest and lowest phosphorus contents (F = 8.72; df = 3.8; $p < 0.01$) were observed in cultivars Dorothea and Persia, respectively. Cultivar Perimer showed the highest potassium content (F = 22.40; df = 3.8; $p < 0.01$). The highest and lowest sodium content (F = 7.68; df = 3.8; $p < 0.05$) was observed in cultivars Dorothea and Persia, respectively.

Discussion

In this research, nutritional indices in three geographic populations of *S. exigua* were measured in response to feeding on four tested sugar beet cultivars. Significant differences were found for the nutritional indices of the pest among the different populations and cultivars.

Approximate digestibility (AD) is one of the main factors among nutritional indices showing nutritional value of food for insect and ability for food uptake through the stomach wall. Variations in AD values show the differences in factors such as poor nutrient value, lack of balance, higher ratio of crude fiber and lower ratio of water (Chapman, 1998). Efficiency of conversion of ingested (ECI) and digested (ECD) food are the other important nutritional indices showing ability of insects to incorporate ingested and digested food into growth and body matter (Nathan *et al.,* 2005). Variations in ECD value indicate the overall changes of metabolized nutrient for energy demand (Koul *et al.,* 2004).

The highest AD values within each population (Table 2) on cultivars Dorothea and Perimer, might be due to lower nutritional value or higher crude fiber of these cultivars for feeding of *S. exigua*. In addition, cultivars Dorothea and Perimer showed the highest concentration of potassium. Digestibility of food for lepidopteran insects is influenced by imbalanced diet or high content of crude fiber in the food (Waldbauer, 1968). Perhaps, one of the possible reasons for this unsuitability might be the role of potassium in host plant resistance against herbivore insects. Potassium can affect the attractiveness of the plant to insects by profound effect on the shape and dissemination of primary metabolites in plant tissues (Amtmann *et al.,* 2008).

Negative effects of high levels of potassium on insect populations could be due to reduced carbohydrate accumulation and amino acids elimination (Baskaran *et al.,* 1985), higher silica content and increase in the sclerenchymous layer (Dale, 1988).

Within each population (Table 2), higher ECI and ECD values on cultivars Rozier and Persia indicated that larvae reared on these cultivars had higher capacity in converting ingested and digested food to body matter. Moreover, cultivars Rozier and Persia showed lower concentration of potassium, phosphorus and sodium than other cultivars. Insects need minerals such as iron, copper, calcium, sodium, potassium ions, phosphorus and sulphur in very small amounts (Nation, 2001). Although, in this study, no significant difference was observed for concentration of nitrogen in the leaves of the four sugar beet cultivars; however, some researchers (Mattson 1980; Scriber and Slansky, 1981), reported that the amount of ingested food by the insects is directly related to the concentration of nitrogen in the host plants. Nitrogen is a fundamental component of proteins and, consequently, for larval growth in initial instar (Scriber, 1983). These results suggested that nutritional status of the host plant can influence the amount of ingested and digested food by the insects. It is well known that chemical and nutritional quality of the ingested food, development stage, energy spent by the insect, and rate of intake into body biomass influenced the amount of food digestion by the insects (David and Gardiner, 1962; Schoonhoven and Meerman, 1978; Kaplan *et al.,* 2014).

Higher RCR value within each population (Table 2) on cultivars Dorothea and Perimer that had higher leaf minerals indicated that the concentration of minerals, especially phosphorus and potassium influenced food consumption by *S. exigua*. Variation in host plant phosphorus and continuous changes in insect body phosphorus affected growth, survival, and development time of the insect (Perkins *et al.,* 2004; Huberty and Denno, 2006).

The highest RGR value (Table 2) of Miandoab population on cultivar Persia, Kalposh population on cultivar Rozier and Moghan population on cultivar Dorothea suggested that these larval populations reared on these cultivars had the highest weight gain and shortest larval period. However, lower RGR value on cultivar Perimer in these populations might be due to lower nutritional value of this cultivar. As reported by Hwang *et al*. (2008), lepidopteran larvae showed higher growth rate and faster development time when they were reared on nutrient-rich food as compared to nutrient-poor food. Moreover, despite the importance of host plant quality on nutritional requirement of the insects, some characters of the insects such as age, sex, physiological stress, reproduction, diapauses or migration (Chapman, 1998; Nation, 2008) and body mass (Phillipson, 1981; Schroeder, 1981), could be affected by their optimal nutritional requirement. Moreover, other reason for RGR reduction on cultivar Perimer, perhaps is the highest concentration of potassium in this cultivar.

The results of this study indicated that different populations reared on local host plant had higher nutritional performances. Higher AD and RCR values in Miandoab population on cultivar Dorothea (as local host plant) and in Kalposh population on cultivar Perimer (as local host plant) might be due to prior feeding experience of these populations on their local host plant.

Conclusions

According to the results of this study, nutritional indices of *S. exigua* do not only differ among cultivars, but also, they vary among geographic populations of *S. exigua*. Although, host plant quality affects nutritional indices of *S. exigua*, when compared with geographic origins of different populations, it is not solely responsible for this variation. On the other hand, it is better to consider suitability or unsuitability of host plants for each population separately. These results indicate that there is a variation among populations in terms of nutritional indices and this might be due to the differences in environmental conditions that the pest was collected from there. This study is the first evidence supporting the effect of geographic origin and host plant cultivar on the nutritional responses of herbivorous insects. In future works, genetic basis of such differences should be studied. The information derived from this study is useful in developing a comprehensive pest management program for *S. exigua.*

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