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Antixenosis Resistance in Sugar Beet Varieties to Long Snout Weevil *Lixus incanescens* Boh. (Col.: Curculionidae)

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***Abstract**.* In plants, antixenosis resistance could reduce injury and yield loss; they can produce selection pressures on insect herbivores that lead to pest resistance. Traditionally, sugar beet long snout weevil, *Lixus incanescens* Boh. (Col.: Curculionidae), is one of the serious pests causing sugar beet losses. In the present study, antixenosis resistance was evaluated in 11 varieties of sugar beet including Pars, Torbat, Ekbatan, SBSI019, Rizofort, Puma, Dorothea, Brigita, Pecora, Nagano and Jolgehin a field trial from 2013 and 2014 years in Qazvin province, Iran. A randomized complete block design with their replications was used. The results showed that in both years, in the first 24 h experiment after release the lowest and highest densities of pest (No. adult/plant) were seen on Pars (2.99) and Dorothea (2.83) varieties, respectively, as opposed the lowest antixenosis resistance were found on Brigita (8.66) and Nagano (8.83) cultivar, whereas on other cultivars showed intermediate values. In Pars, Brigita and Nagano varieties the number of adult weevils (adult/plant) increased rapidly during the first 24 h, but after which there was a decline to the minimum on about the fifth day. The results of data analysis to investigate the mechanism of free choice antixenosis in the years 2013 and 2014 showed that there are no significant differences between experimental blocks and among cultivars tested. As a result, our findings showed that above mention variety can be used in integrated management plans of sugar beet long snout weevil, and with regionally adapted varieties and excellent seed quality we strive for excellent varietal performance in all growing regions of the Iran.
***Keyword**:* Antixenosis, *Lixus incanescens*, Resistance, Sugar beet, Weevil.

Introduction

Knowledge of the extent of susceptibility or resistance of cultivars as well as biology of a pest on a crop is a fundamental component of an integrated pest management program for any crop and can provide information on the detection and monitoring of pest infestations, cultivar selection and crop breeding [GOLIZADEH *et al.*, 2016, ROTARU, *et al.*, 2011, STEFAN, *et al.*, 2013].

Based on our knowledge, damage rate in early–planted sugar beet is less than late–planted ones, thus, the percentage of damage is related to date of planting. Traditionally, the sugar beet long snout weevil, *Lixus incanescens* Boh. (Col: Curculionidae) has three generations per year and serious pests causing sugar beet losses. Always severe damage happens in the second generation in August. The economic losses due to *L. incanescens* family damage were increased in Iran.

Especially in recent years, it has become the most important pest of sugar beet cultivation. In 1994 Ocete and colleagues reported that the larvae can cause up to 75 % root weight loss [OCETE *et al.*, 1994, MIHALACHE, *et al.*, 2016, ROTARU, *et al.*, 2010].

Basically, to control *L. incanescens*, farmers have to repeatedly use of pesticides with a wide spectrum to manage the high population of this pest, but often these efforts are not successful, because all immature stages are located the petioles [FOSTER *et al.*, 2007, STEFAN, *et al.*, 2013, STOLERU, *et al.*, 2015] and has led to resistance of various *L. incanescens*. Host plant resistance is an alternative method for pest management, since it is both economically and environmentally

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acceptable [KARIMI et al., 2012, SELLITTO, et al., 2016, STAVARACHE, et al., 2015].

Methods to increase sugar beet resistant cultivars could help farmers to decline pest population density and subsequently less damage to their plants.

Although host plant resistance is an important component of an integrated pest management strategy for the control of sugar beet long snout weevil [KHANJANI, 2004 DIMITRIU, et al., 2016, HAMBURDA, et al., 2016], little information has been available on levels of host plant resistance to long snout sugar beet weevil [VARDANIAN, et al., 2018, RASHED and BUTNARIU, 2014].

In recent years, release of different varieties of sugar beet with diverse quantitative and qualitative characteristics gradually has increased yield and reduced pest losses in the world.

So far, based on our knowledge no comprehensive study in Iran is done about antixenosis resistance in sugar beet varieties to sugar beet long snout weevil and its damage to different varieties of sugar beet.

Therefore, the main aim of the present study was to investigate the antixenosis resistance in eleven sugar beet varieties to long snout weevil *L. incanescens* in Iran.

Material and methods

Location and Plant materials. This study was performed at Pistachio Research Station at Yezbar village Qazvin Province, Iran (36° 2'N, 50° 7'E, 1175 m above sea level). Seeds of eleven commercial monogerm cultivars of sugar beet, including: Pars, Torbat, Ekbatan, SBSI019, Rizofort, Puma, Dorothea, Brigita, Pecora, Nagano and Jolgeh, were obtained from Seed and Plant Breeding Research Institute, Karaj, Iran.

Preparing land and insect colony. Field testing was achieved in an area of about 0.1 hectare, in the early spring of 2013 and 2014 that was deeply plowed.

After tight and weeding, planting seeds of sugar beet varieties were conducted in the second decade of April each year. Farm irrigation every 7 to 10 days were routine. Weed control was performed by hand removing. Adult's weevils were collected from a sugar beet (*B. vulgaris*) field.

Evaluation of antixenosis index. To evaluate antixenosis index, the free choice test was conducted based on the randomized complete block design with their replications. Replications were three circular furrows with 1.5 m radius in which treatments randomly planted at a distance of 10 cm from each other.

Distance between furrows was 2 m. Two months after planting, when plants had 10 to 12 leaf, 50 adults *L. incanescens* were released in the center of each furrow. At time of intervals of 24, 48, 72, 96 and 120 h, the number of adults weevils attracted to each plant was counted (the number of adults weevils attracted to each treatment was considered as an antixenosis index). To prevent escaping, furrows was surrounded by white nets (Figure 1).


Figure 1. Two replications prepared for testing antixenosis index in sugar beet

Statistical analysis. The data are shown as mean ± standard deviation (mean±SD). Prior to analysis, heterogeneity of variance was tested and then all entries were transformed [Log(X+2)]. Numbers of adult weevils deployed at the different times on eleven sugar beet cultivars at two–years were analyzed based on combined analysis of randomized complete block design.

Significance of the differences was examined by analysis of variance (ANOVA) test., followed using Tukey post hoc. The levels of significance were done at α=0.05. Statistical analysis was performed by SAS® 9.1 software (2005).

Results and discussion

Mean comparison of treatments in 2013 (Table 1) showed that in the first 24 h experiment, number of adults weevils attracted to the plant varieties Rizofort, Pars and Drothea were lower than others and these varieties have high antixenosis characteristics.

On Pars cultivar, antixenosis quality were generally found to have the upmost developmental, whereas the lowest antixenosis resistance were found on Brigita and Nagano cultivar.

Means comparison in 2013 showed that Pars variety has higher level of antixenosis quality.

Table 1.

Means comparison of adult weevils settled on different sugar beet cultivars in the free choice antixenosis test in 2013 (Means ± SE)

Cultivar (No. adult/plant)	24 h	48 h	72 h	96 h	120 h
Pars	2.33±0.33f	2.00±0.00f	1.33±0.33f	1.66±0.33d	0.33±0.33e
Torbat	6.33±0.33bc	5.66±0.33bc	7.66±0.33a	4.33±0.33b	3.66±0.33bc
Ekbatan	5.66±0.33cd	4.66±0.33cd	6.33±0.33ab	2.66±0.33cd	1.66±0.33de
SBSI019	3.66±0.33ef	10.66±0.33a	4.66±0.33cd	2.33±0.33cd	1.00±0.00e
Rizofort	0.66±0.33g	2.66±0.33ef	5.66±0.33bc	1.66±0.33d	2.66±0.33cd
Puma	3.66±0.33ef	6.66±0.33b	5.33±0.33bc	3.00±0.00bcd	3.33±0.33bc
Drothea	2.66±0.33f	3.66±0.33de	5.33±0.33bc	7.33±0.33a	8.66±33.0a
Brigita	8.33±0.33a	5.66±0.33bc	3.33±0.33de	1.66±0.33d	1.33±0.33de
Pecora	7.66±0.33ab	6.66±0.33b	5.66±0.33bc	3.33±0.33bc	1.66±0.33de
Nagano	8.33±0.33a	6.66±0.33b	5.33±0.33bc	4.33±0.33b	1.66±0.33de
Jolgeh	4.33±0.33de	4.66±o.33cd	2.33±0.33ef	4.33±0.33b	4.66±0.33b

Mean values in a column followed by different lowercase letters (a–g) are significantly different on the basis of ANOVA with Tukey's test ($p<0.05$)

In 2014, Rizofort with mean number of 1.33 adult weevils attracted to the plant 24 h experiment after release classified in the group with antixenosis mechanism, while at this time Nagano and Brigita with means number of 9.33 and 9.00 attracted adult weevils were in the group without antixenosis property.

In addition, there were significant differences among the sugar beet varieties for antixenosis test ($p<0.05$) and results confirms that the proper level of antixenosis resistance on the Pars and Rizofort varieties and relatively resistant to *L. incanescens*.

Means comparison in 2014 showed that Drothea variety has higher level of antixenosis quality (Table 2).

Table 2.

Means comparison of adult weevils settled on different sugar beet cultivars in the free choice antixenosis test in 2014 (Means ± SE)

Cultivar (No. adult/plant)	24 h	48 h	72 h	96 h	120 h
Pars	3.66±0.33cd	2.66±0.33e	1.66±0.33e	3.00±0.00cd	1.00±0.00fg
Torbat	6.66±0.33b	6.00±0.57bc	8.33±0.33a	4.00±0.00bc	4.66±0.33b
Ekbatan	5.33±0.33bc	5.00±0.00cd	7.00±0.00ab	3.33±0.33bcd	2.66±0.33cd
SBSI019	4.33±0.33cd	8.66±33.0a	5.00±0.00cd	3.33±0.33bcd	0.00±0.00g
Rizofort	1.33±0.33e	3.33±0.33de	6.33±0.33bc	2.33±0.33d	3.00±0.00cd
Puma	3.66±0.33cd	6.66±0.33abc	5.33±0.33bcd	3.00±0.00cd	3.66±0.33bc
Drothea	3.00±0.00de	2.66±0.33e	6.00±0.00bcd	7.66±0.33a	10.33±0.33a
Brigita	9.00±0.57a	5.66±0.88bc	4.33±0.33d	2.00±0.00d	0.33±0.33fg
Pecora	6.33±0.33b	7.66±0.33ab	5.66±0.33bcd	4.33±0.33bc	2.33±0.33de
Nagano	9.33±0.33a	5.66±0.33bc	5.33±0.33bc	4.66±0.66b	1.33±0.33ef
Jolgeh	3.33±0.33d	5.00±0.00cd	1.66±0.33e	4.66±0.33b	3.66±0.33bc

Mean values in a column followed by different lowercase letters (a–g) are significantly different on the basis of ANOVA with Tukey's test ($p<0.05$)

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The results showed that in both years, in the first 24 h experiment after release the lowest and highest densities of pest (No. adult/plant) were seen on Dorothea (2.83) and Pars (2.99) varieties, respectively, as opposed the lowest antixenosis resistance were found on Brigita (8.66) and Nagano (8.83) cultivar, whereas on other cultivars showed intermediate values. In Pars, Brigita and Nagano varieties the number of adult weevils (adult/plant) increased rapidly during the first 24 h, but after which there was a decline to the minimum on about the fifth day. The results of data analysis to investigate the mechanism of free choice antixenosis in the years 2013 and 2014 (Table 3) showed that there are no significant differences between experimental blocks and among cultivars tested. On the other hand, among experimental blocks, significant differences were observed on the fifth days ($p<0.05$). Also, interaction between of year × Cultivar in the third and fourth days was no significantly different.

Table 3.

Combined analysis of free choice antixenosis test for compression adult weevils settled on different sugar beet cultivars during 2013 and 2014 years (Means ± SE)

S.O.V. (No. adult/plant)	Df	24 h	48 h	72 h	96 h	120 h
Year	1	0.742^{NS}	0.060^{NS}	2.969^{**}	4.378^{**}	0.742^{NS}
Block (year)	4	0.424^{NS}	0.606^{NS}	0.606^{NS}	0.303^{NS}	0.696^{*}
Cultivar	10	38.081^{**}	26.742^{**}	22.260^{**}	15.478^{**}	39.275^{**}
Year × Cultivar	10	1.009^{**}	1.227^{**}	0.369^{NS}	0.345^{NS}	1.275^{**}
Error	40	0.340	0.389	0.306	0.303	0.230
C.V.	–	11.712	11.568	10.997	15.329	16.582

NS: non–significant, *: $p<0.05$ and **: $p<0.01$

The sugar beet has been considered to be one of the most important production constraints on farming fields in Qazvin province, Iran.

The results present study has revealed a wide range of host plant responses to sugar beet long snout weevil, between sugar beet cultivars.

And the results of this study can be used in selection of suitable cultivar with high antixenosis resistance, lower pest density and lower pest loss.

Traditionally, antixenosis is the resistance mechanism exhibited by a plant to deter settlement and colonization of an insect [CAUNII, *et al.,* 2015, BUTU, *et al.,* 2015, STOLERU, *et al.,* 2012, SAMFIRA et al., 2015]. Evaluating the resistance through population growth parameters of an insect can indicate the degree of plant resistance to insects [TSAI and WANG, 2001, BUTNARIU, *et al.,* 2015, BUTU, *et al.,* 2014c].

Thus, the life table parameters estimated to long Snout Weevil *L. incanescens* on eleven sugar beet cultivars selected from the screening test detected relatively susceptible and resistant cultivars to this pest. Our results clearly showed that different sugar beet cultivars have significant antixenosis effects on *L. incanescens* and the authors suggest that reduced susceptibility of Pars to *L. incanescens* would lead to lower pest infestation in the field.

Drothea cultivar had the highest host antixenosis resistance among the tested cultivars with a high potential to be used in the integrated management of *L. incanescens*. The faster lower fecundity rate and development rate are reflected in the lowest intrinsic rate of decrease of *L. incanescens* on Drothea, and this would result in lower population growth that in turn should lead to lower subsequent infestations [IANCULOV, *et al.,* 2004].

The number of adult *L. incanescens* attracted to each cultivar indicated that the ability of antixenosis resistance of its cultivar.

While, Golizadeh and coworkers reported that antixenosis had no effect in resistance against *Aphis fabae* in 5 sugar beet cultivars (Doroti, Perimer, Pershia, Rozier and 006) [GOLIZADEH *et al.,* 2016].

These results agree with earlier reports published by Fathi and Abedi, in which they evaluated 6 cultivars namely Ardabili (polygerm), Aras, Persia, Flores, Rosire and Laetitia (monogerm) under field condition and reported that the lowest and the highest densities of weevil were observed on Persia and Ardabili cultivars, respectively [FATHI and ABEDI, 2014, STOLERU, *et al.*, 2016, GEORGIEVA, *et al.*, 2018].

In general, according to the results of this study can be concluded that among the varieties studied Drothea with the highest density of adult weevils was more favorable to sugar beet long snout adults, while Pars with the fewest density of adult weevils was undesirable to sugar beet long snout adults [BUTU, *et al.*, 2014b].

Therefore, it can be concluded that Pars cultivation in combination with other methods of pest management controls can be useful in sugar beet fields in the Qazvin, Iran. In 2013 Stout proposed a dichotomous tolerance/resistance scheme that better reflects the strategies available to plants for reducing the impact of herbivores and better incorporates the known range of resistance mechanisms [STOUT, 2013, PETRACHE, *et al.*, 2014].

Results confirms that the high level of antixenosis resistance on the Drothea, Brigita, Nagano and Pecora varieties to *L. incanescens*, which could prove useful in the development of farming programs in sugar beet fields [RODINO, *et al.*, 2014, BUTNARIU, *et al.*, 2016, STOLERU, *et al.*, 2018].

As a result, Drothea variety can be used in the integrated management of sugar beet long snout weevil in farms of Qazvin province. In 2014 Fathi and Abedi observed that leave the sugar beet long Snout adults from host plants (petiole of sugar beet leaves) as a mechanism of resistance. It seems that morphology barriers and anti–nutritional compounds leaves are the main factor of resistance mechanism.

Also, they indicated that the weevil larvae produced shorter mines on the petioles of Persia than on Ardabili, Aras, Flores and Rosire, but the length of mines on the petioles of Persia did not show significant difference compared with Laetitia [FATHI and ABEDI, 2014, BUTU, *et al.*, 2014a, BUTNARIU, 2016, BUTNARIU and SAMFIRA, 2012].

Results showed that *L. incanescens* is one of the most important pests of sugar beet fields in Iran [RASHIDOV and KHASANOV, 2003].

These results a line with Rashidov and Khasanov that reported this pest most important in other countries such as Russia, Ukraine, Turkmenistan, Uzbekistan and Turkey.

Conclusions

In conclusion, considering the antixenosis resistance of various sugar beet cultivars and crop species to long Snout Weevil *Lixus incanescens* Boh. (Col.: Curculionidae) could offer useful information about their unsuitability or suitability for the target pest species.

Also, the number of adult *L. incanescens* attracted to each cultivar indicated that the ability of antixenosis resistance of its cultivar.

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Conflict of interest

The authors report that they have no other financial or personal relationships that could inappropriately influence or bias the content of the paper.

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