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Article

Screening of 55 pinto bean lines for resistance to the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae)

Zarir Saeidi

Department of Plant Protection, Agricultural and Natural Resources Research and Education Center, Chaharmahal va Bakhtiari, AREEO, Iran; E-mail: zarirsaeidi@yahoo.com

ABSTRACT
Two-spotted spider mite (TSSM) (*Tetranychus urticae* Koch) is considered as the most important pest of bean in different parts of the world. In this study, 55 lines selected from different germplasms of pinto bean, were screened for resistance to the TSSM in two stages. In the first stage, they were classified into five groups based on the intensity of damage to their leaf disks (from 0, without damage to 6, feeding patches more than 80% of leaf area). Twenty-one lines presented the highest leaf damage index (LDI = 5.30 ± 0.27), therefore, they were excluded from subsequent experiments, except line 'D_{521}', which was used as the susceptible check. In the second stage, 34 lines with LDI less than 4, along with line 'D_{521}' (as susceptible), were studied using leaf disk bioassay. Based on the results, line 'D_{521}' (7.52 ± 1.23 eggs/female/day) supported the highest, whereas, lines 'L_1' (1.46 ± 0.23), 'J_{29}' (1.60 ± 0.26) and 'L_{19}' (1.69 ± 0.59 eggs/female/day) supported the lowest level of oviposition. The highest and lowest level of damage was observed on leaf disk of 'D_{521}' (5.5 ± 0.40) and 'L_{19}' (1.8 ± 0.37), respectively. The studied lines were classified into five groups, based on the mite response to the host (oviposition and mortality) and host response to the mite (damage score). In the cluster analysis, lines 'D_{521}', 'J_{633}', 'D_{524}' and 'D_{532}' appeared to be highly susceptible and susceptible, whereas, lines 'L_{31}', 'L_{329}', 'L_{321}', 'L_{16}', 'B_{417}', 'B_{425}', 'L_{328}', 'J_{29}', 'J_{67}', 'L_{19}', 'D_3', 'L_{25}' and 'L_1' were resistant to TSSM, which can be used as the source of resistance in future plant breeding programs.

KEY WORDS: Cluster analysis; infestation; leaf damage index; leaf disk bioassay; susceptibility.

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INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is one of the most important and widely grown crops in the world, cultivated commercially in many parts (e.g. Markazi, Lorestan, Chaharmahal va Bakhtiari, Fars and Zanjan provinces) of Iran (Saeidi and Salehi 2005; Modarres Njafabadi and Zamani 2013). Among different pests attacking this crop, the two-spotted spider mite (TSSM) (*Tetranychus urticae* Koch) is considered as the most important pest causing serious damage by sucking leaves' cell contents (Saeidi and Salehi 2005). During favorable conditions (hot and dry season), mite population increases rapidly, plant foliage gets covered with webbing, the leaves turn yellowish and drop off (Godfrey 2011) and the seed quantity and quality gets significantly reduced (Saeidi 2011).

Because of the short life span, high fecundity and ability of TSSM to develop resistance to many acaricides, an integrated program is essential for sustainable management of its population (Luczynski *et al.* 1990). Host-plant resistance, as an inseparable element of integrated pest management (IPM) program, is not only compatible with other methods of control (Lorenzen *et al.*

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2001), but also, in many cases, useful to enhance the efficiency of biological control agents (Bong *et al.* 1991). Use of host plant resistance is widely known as an efficient, economical, ecological and socially advantageous control method within IPM programs (Stenberg 2017).

Host plant resistance to the two-spotted spider mite has been reported in different crops such as raspberry (Wilde *et al.* 1991), strawberry (Gimenez-Ferrer *et al*. 1994), tomato (Saeidi and Mallik 2006), soybean (Sedaratian *et al.* 2009), eggplant (Khanamani *et al.* 2012), almond (Saeidi 2013), bean (Modarres Njafabadi and Zamani 2013; Mohammadi *et al*. 2013), cucumber (Mohammadi *et al.* 2015) and peach (Riahi *et al.* 2020). Different studies have been done on the biology and life table parameters of the TSSM on different bean varieties, but a few lines or varieties of pinto bean are reported as resistant to the mite. Screening techniques help us to identify resistant lines or varieties (among large number of individuals), and eliminate the majority of susceptible ones (Panda and Khush 1995). Therefore, the present study was performed to select resistant lines among different genotypes of pinto bean which can be used by the breeders in future bean breeding programs.

MATERIAL AND METHODS

Plant materials

Nine accessions from different parts of Chaharmahal va Bakhtiari province, Iran, including Lordegan (6 accessions), Boldaji, Dastgerd (Kiar) and Joneghan (one accession from each) were collected. Fifty seeds from each accession were planted in the field under natural conditions and artificially infested by introducing five adult females per plant at seedling stage (two-leaf stage). Those lines (totally 54) which survived till harvesting stage and produced vigorous seeds were selected and studied under greenhouse and laboratory conditions along with the commercial variety of "Talash" (as control). Lines which originated from Lordegan, Boldaji, Dastgerd and Joneghan accessions are shown by letters L, B, D and J, respectively.

Maintenance of the mite culture

The strain of *T. urticae* used in this study originated from infested leaves of bean, *P. vulgaris*, collected from Lordegan fields. Mite rearing was carried out on 'Talash' variety under greenhouse conditions. The individual mites used for the experiments were collected and transferred to the plants using a fine camel hair brush.

Screening for resistance to the two-spotted spider mite

Screening for resistance to the TSSM was carried out at two stages. In the first stage, 55 lines, selected from different accessions of pinto bean, were studied based on the leaf damage score. The experiment was conducted based on the completely randomized design (CRD) under greenhouse conditions (25 ± 2 ºC, RH 50 ± 10% and photoperiod 14 L: 10 D) in three replicates. Each replicate contained three pots. Plants were sown in pots (15 × 20 × 20 cm) and watered daily. They were covered by insect proof nets to avoid any contamination. Infestation of the lines was done when the plants were at two-leaf stage by introducing five adult females (3 days in age). After two weeks, five leaves of each plant were selected randomly and scored based on the intensity of damage (from 0, without damage to 6, feeding patches more than 80% of leaf area).

Leaf damage index (LDI): LDI scored on a 0 to 6 scale, based on the intensity of damage described by Nihoul *et al.* (1991), Gimenez-Ferrer *et al.* (1993) and Saeidi and Mallik (2006) as:

0 = no damage
1 = Few small feeding patches < 10 % of leaf area.
2 = Feeding patches 10–25 % of leaf area
3 = Feeding patches 26–40 % of leaf area
4 = Feeding patches 41–60 % of leaf area

5 = Feeding patches 61–80 % leaf area
6 = Feeding patches 81–100 % of leaf area

Second stage

Thirty-three lines (with LDI less than 5) along with line 'D_{521}' (LDI = 5) and 'Talash' variety (as control) were studied based on the leaf disk bioassay. Plants were grown under greenhouse conditions (as described above) based on the completely randomized design in three replicates.

Leaf disk bioassay

Four weeks after sowing, when the plants were at 5–6 leaf stages, two leaves from each plant (totally 6 leaves from each treatment) were collected from equivalent positions (3rd and 4th leaves from the top) and used for leaf disk bioassay. Leaf disks (2 cm diameter) were obtained from either side of the main vein and placed with abaxial surface facing up on a water-saturated none-sterile cotton wad in a plastic Petri dish (12 cm diameter). For bioassay, five adult female mites (3 days in age) were introduced on each disk and kept in an incubator (25 ± 2 ºC, RH 50 ± 10% and photoperiod 14 L: 10 D). After 72 h, the number of laid eggs and number of alive mites on each disk were recorded. Moreover, LDI scored on a 0 to 6 scale after 96 h, as previously described (Gimenez-Ferrer *et al.* 1993; Saeidi and Mallik 2006).

Statistical analysis

Statistical analysis was performed using SAS (version 9.1) and SPSS (version 22) software. Analysis of variance (Proc ANOVA) was performed to identify significant differences among the treatments and means compared using LSD test at 5% level. To compare non-parametric data, Kruskal-Wallis test was used. Proc Clus was performed for grouping different lines based on 1 to 6 scales. Proc Corr was used for identifying the relation between variables. Data normality was assessed using Kolmogorov–Smirnov test and, data conversion was performed using the formula $\sqrt{x}$ + 1, if required.

RESULTS

First stage

Studied lines were classified into five groups based on the leaf damage index (Table 1). Based on the results, lines 'L_{19}' and 'L_1' showed the lowest leaf damage index (LDI = 1.2 ± 0.18). Nine lines including 'L_{31}', 'L_{329}', 'L_{321}', 'L_{16}', 'B_{425}', 'J_{29}', 'J_{67}', 'D_3' and 'L_{25}' showed 10 to 25% feeding patches on their leaves (LDI = 2.5 ± 0.35). Thirteen lines exhibited 26 to 40 % (LDI = 3.70 ± 0.25), whereas 10 lines showed 41 to 60% of feeding patches on their leaf area, respectively. Twenty-one lines presented the highest LDI (feeding patches 61 to 80%), therefore, all of them, except line 'D_{521}', were removed. Finally, 34 lines with LDI less than 4.60 ± 0.32, along with line 'D_{521}' (as susceptible) were selected for further studies.

Second stage

Selected lines were classified in different groups based on the mite oviposition, mite mortality and leaf damage index.

Mite oviposition and mortality

Studied lines significantly influenced the oviposition response of TSSM females. The highest level of oviposition (number of eggs/female/day) was supported by line 'D_{521}' (7.52 ± 1.23) followed by line 'J_{632}' (6.72 ± 0.68), whereas, line'L_1' supported the lowest level of oviposition (1.46 ± 0.23) followed by lines 'J_{29}' (1.60 ± 0.26) and 'L_{19}' (1.69 ± 0.59) (Table 2). The highest

number of alive mites (out of 5 mites) were recorded on lines 'J_{617}' (4.90 ± 0.10) and 'B_{432}' (4.75 ± 0.20), whereas the lowest were on lines 'L_{329}' (1.2 ± 0.2) and 'L_{19}' (1.40 ± 0.4) (Table 2).

Table 1. Grouping of 55 lines of pinto bean, *Phaseolus vulgaris,* for resistance to *Tetranychus urticae* based on mean (± SE) leaf damage score.

Clusters	Leaf damage score	Lines
Highly Susceptible	5.30 ± 0.27	'L_{12}', 'L_{13}', 'L_{14}', 'L_{15}', 'L_{17}', 'L_{18}', 'L_{20}', 'L_{21}', 'L_{22}', 'L_{23}', 'L_{24}', 'L_{26}', 'L_{27}', 'L_{28}', 'L_{32}', 'L_{33}', 'L_{34}', 'L_{35}', 'L_{36}', 'L_{37}', 'D_{521}'
Susceptible	4.60 ± 0.32	'D_{524}', 'D_{532}', 'L_{323}', 'J_{617}', 'L_{125}', 'B_{432}', 'D_{534}', 'L_{120}', 'J_{632}', 'D_{526}'
Moderate Susceptible	3.70 ± 0.25	'L_{236}', 'L_{29}', 'L_{30}', 'L_{42}', 'Talash', 'J_{633}', 'D_{56}', 'J_{625}', 'B_{45}', 'B_{433}', 'B_{417}', 'L_{328}', 'L_{229}'
Moderate Resistant	2.50 ± 0.35	'L_{31}', 'L_{329}', 'L_{321}', 'L_{16}', 'B_{425}', 'J_{29}', J_{67}, 'D_3', 'L_{25}'
Resistant	1.20 ± 0.18	'L_{19}', 'L_1'

Table 2. Comparison (mean ± SE) of two-spotted spider mite oviposition and mortality and leaf damage score on 35 lines of pinto bean in leaf disk bioassay.

Lines	No. eggs[1]	No. of alive mites[2]	No. of dead mites[2]	Damage score
'D_{521}'	112.80 ± 18.53 a	4.20 ± 0.37 a-d	0.80 ± 0.37 h-k	5.50 ± 0.40
'J_{632}'	100.80 ± 10.20 a-b	4.00 ± 0.54 a-e	1.00 ± 0.54 g-k	4.80 ± 0.37
'D_{524}'	98.50 ± 14.14 a-b	3.75 ± 0.47 a-f	1.25 ± 0.47 f-k	5.00 ± 0.40
'D_{532}'	95.00 ± 17.19 a-c	4.50 ± 0.50 a-c	0.50 ± 0.10 i-k	5.40 ± 0.24
'L_{323}'	88.40 ± 13.68 a-d	4.00 ± 0.54 a-e	1.00 ± 0.14 g-k	5.00 ± 0.54
'J_{617}'	82.75 ± 8.41 b-e	4.90 ± 0.10 a	0.10 ± 0.03 k	4.75 ± 0.25
'L_{236}'	72.25 ± 13.68 b-f	3.70 ± 0.25 a-f	1.30 ± 0.25 f-k	3.50 ± 0.10
L_{125}''	71.00 ± 12.72 b-f	3.80 ± 0.37 a-f	1.20 ± 0.37 f-k	4.60 ± 0.24
'B_{432}'	66.25 ± 11.34 c-g	4.75 ± 0.20 a-b	0.25 ± 0.05 j-k	4.75 ± 0.25
'D_{534}'	66.20 ± 7.00 c-g	4.20 ± 0.37 a-d	0.80 ± 0.17 h-k	4.80 ± 0.20
'D_{526}'	65.50 ± 5.33 c-g	3.00 ± 0.40 c-g	2.00 ± 0.40 c-i	5.00 ± 0.40
'L_{29}'	64.50 ± 11.80 c-g	3.75 ± 0.62 a- f	1.25 ± 0.32 f-k	4.00 ± 0.70
'L_{30}'	64.25 ± 10.80 c-g	3.50 ± 0.50 b-g	1.50 ± 0.50 e-j	4.25 ± 0.47
'L_{120}'	61.00 ± 4.70 e-h	4.25 ± 0.25 a-d	0.75 ± 0.25 h-k	4.50 ± 0.28
'L_{42}'	56.50 ± 6.65 e-i	2.25 ± 0.25 g-k	2.75 ± 0.25 a-e	4.25 ± 0.47
'Talash'	56.50 ± 5.55 e-i	3.33 ± 0.49 b-h	1.67 ± 0.49 d-j	4.17 ± 0.40
'L_{229}'	51.20 ± 7.06 f-j	1.80 ± 0.48 i-k	3.20 ± 0.48 a-c	3.20 ± 0.58
'J_{633}'	46.20 ± 4.36 f-j	2.00 ± 0.31 h-k	3.00 ± 0.31 a-d	4.00 ± 0.31
'D_{56}'	44.80 ± 5.85 f-j	3.20 ± 0.66 c-g	1.80 ± 0.66 c-i	3.80 ± 0.48
'J_{625}'	42.75 ± 7.65 f-j	4.00 ± 0.40 a-e	1.00 ± 0.40 g-k	4.00 ± 0.40
'B_{45}'	42.4 0 ± 9.91 f-j	3.60 ± 0.40 a-e	1.40 ± 0.40 e-k	3.20 ± 0.48
'B_{433}'	42.20 ± 6.37 f-j	1.80 ± 0.37 a-f	3.20 ± 0.37 a-c	3.20 ± 0.37
'L_{31}'	38.75 ± 5.96 g-j	1.75 ± 0.47 i-k	3.25 ± 0.47 a-c	3.00 ± 0.40
'L_{329}'	36.00 ± 6.98 g-j	1.20 ± 0.20 k	3.80 ± 0.20 a	2.80 ± 0.58
'L_{321}'	35.00 ± 7.00 g-j	2.60 ± 0.40 e-k	2.40 ± 0.40 a-g	2.80 ± 0.37
'L_{16}'	36.00 ± 4.21 g-j	2.60 ± 3.10 e-k	2.30 ± 0.80 a-g	2.60 ± 0.35
'B_{417}'	35.00 ± 4.59 g-j	4.20 ± 0.37 a-d	0.80 ± 0.37 h-k	3.60 ± 0.40
'B_{425}'	31.20 ± 6.80 h-j	1.80 ± 0.20 i-k	3.20 ± 0.20 a-c	3.00 ± 0.31
'L_{328}'	30.80 ± 5.32 h-j	1.80 ± 0.66 i-k	3.20 ± 0.66 a-c	3.20 ± 0.37
'D_3'	29.40 ± 3.82 h-j	3.40 ± 0.60 b-h	1.60 ± 0.60 d-j	3.00 ± 0.10
'J_{67}'	27.80 ± 8.78 i-j	2.40 ± 0.40 f-k	2.60 ± 0.40 a-f	2.80 ± 0.66
'L_{19}'	25.40 ± 8.93 i-j	1.40 ± 0.40 j-k	3.60 ± 0.40 a-b	1.80 ± 0.37
'J_{29}'	24.00 ± 3.96 j	3.20 ± 0.37 c-g	1.80 ± 0.37 c-i	2.60 ± 0.37
'L_{25}'	23.25 ± 4.57 j	2.00 ± 0.10 h-k	3.00 ± 0.10 a-d	2.25 ± 0.47
'L_1'	22.00 ± 3.42 j	2.80 ± 0.37 d-j	2.20 ± 0.37 b-h	2.80 ± 0.37

[1]Number of eggs/5 females/3 days [2]number out of 5 mites
Lines with the same letter at each column are not significantly different at $P = 0.05$

Leaf damage

Kruskal-Wallis test showed significant differences among the treatments (Table 3). The highest level of damage (LDI) was observed on the leaf disk of 'D_{521}' and 'D_{532}' (5.50 ± 0.40 and 5.40 ± 0.24, respectively), whereas the leaf disk of 'L_{19}' (1.80 ± 0.37) and 'L_{25}' (2.25 ± 0.47) had the lowest values of LDI (Table 2).

Overall performance

The correlation between mite oviposition and leaf damage score was strongly positive (R = 0.83, P = 0.0001) whereas, the correlations between mite mortality and leaf damage score was strongly negative (R = −0.62, P = 0.0001). The studied lines were classified into five groups, based on the overall performance in leaf disk bioassay. Mite response to the host (oviposition and mortality) and plant response to the mite (leaf damage score) were considered simultaneously as a measure of overall performance (Table 3). In the cluster analysis, lines 'D_{521}', 'J_{633}', 'D_{524}' and 'D_{532}' appeared to be highly susceptible and susceptible, whereas, lines 'L_{31}', 'L_{329}', 'L_{321}', 'L_{16}', 'B_{417}', 'B_{425}', 'L_{328}', 'J_{29}', 'J_{67}', 'L_{19}', 'D_3', 'L_{25}' and 'L_1' appeared to be resistant to the TSSM (Table 3).

Table 3. Grouping of 35 lines of pinto bean, *Phaseolus vulgaris*, for resistance to *Tetranychus urticae* based on mean (± SE) mite oviposition, mite mortality and leaf damage score.

Clusters	No. eggs	Mite mortality	Leaf damage score	Lines
Highly Susceptible	112.8 ± 1.50	0.8 ± 0.10	5.4 ± 0.24	'D_{521}'
Susceptible	98.1 ± 2.92	0.92 ± 0.38	5.1 ± 0.36	'J_{633}', 'D_{524}', 'D_{532}'
Moderate Susceptible	85.5 ± 3.99	0.5 ± 0.7	4.87 ± 0.18	'L_{323}', 'J_{617}', 'L_{236}', 'L_{125}', 'B_{432}', 'D_{534}', 'L_{526}'
Moderate Resistant	63.2 ± 6.35	1.5 ± 0.85	4.27 ± 0.55	'L_{29}', 'L_{30}', 'L_{120}', 'L_{42}', 'Talash', 'L_{229}', 'J_{633}', 'D_{56}', 'J_{625}', 'B_{45}', 'B_{433}'
Resistant	33.98 ± 7.98	0.92 ± 0.92	0.58 ± 0.58	'L_{31}', 'L_{329}', 'L_{321}','L_{16}', 'B_{417}', 'B_{425}', 'L_{328}', 'J_{29}', J_{67}, 'L_{19}', 'D_3', 'L_{25}', 'L_1'

DISCUSSION

Host plant quality affects the development, survival and fecundity of *T. urticae* (Uddin *et al*. 2015). Our results indicated that studied lines of pinto bean were significantly different in their suitability to the feeding, survival and oviposition of TSSM females (Table 2). Differences in host suitability for the mite are reported by several authors. Rasmy (1985) and Saeidi and Mallik (2006) studied differences in suitability of *Lycopersicon* species for the mite oviposition, survival and development. Mohammadi *et al*. (2015) studied reproductive parameters, life expectancy and life table parameters of this mite on six greenhouse cucumber cultivars. All of these studies suggested the existence of genetic factors which influence the suitability of the host plant for TSSM.

In the present study, 55 genotypes of *P. vulgaris* were screened using leaf disk bioassays based on the mite oviposition and mortality and plant damage score. This method has been used successfully for *in vitro* screening of several crops to the TSSM such as raspberry, *Rubus idaens* L., (Wilde *et al.* 1991), strawberry, *Fragaria* sp. (Gimenez-Ferrer *et al.* 1993), tomato, *Lycopersicon* species (Saeidi and Mallik 2006), white bean, *P. vulgaris* (Mohammadi *et al.* 2013) and cucumber, *Cucumis sativus* L. (Mohammadi *et al*. 2015). The *in vitro* method (leaf disk bioassay) used here, is an effective method for studying resistance to the TSSM (Saeidi and Mallik 2006; Mohammadi *et al.* 2013) and clearly indicated differences among the tested lines (Tables 1–3). However, because the host environment relationship is extremely complex, selected lines should be subjected to complementary experiments under field conditions.

Studied lines were classified into five groups (highly susceptible, susceptible, moderate susceptible, moderate resistant and resistant) according to mite response to the host (oviposition and mortality) and host response to the mite (leaf damage score) (Table 3). Determining relative resistance among the host plants could be more clearly established when mite response to the host and host response to the mite are considered simultaneously as a measure of overall cultivar performance (Gimenez-Ferrer *et al.* 1993).

Differences observed among the treatments in the mite and plant responses may indicate the presence of genetic factors which influence antibiotic, antixenotic or tolerance mechanisms. According to Shoorooei *et al.* (2018), both antixenosis and antibiosis mechanisms to the TSSM were observed in resistant accessions of common bean. Among the 55 studied lines, only 13 lines were resistant to the TSSM (Tables 2, 3), which can be used as the source of resistance to the TSSM in future plant breeding programs. Understanding the genetic basis of resistance in the selected lines will facilitate transferring of resistant genes to the commercial cultivars of pinto bean. Resistant cultivars not only minimize pest damage and guarantee stability of production (Saeidi and Mallik 2006), but also present an appropriate solution to reduce application of dangerous-to-environmental -health pesticides (Fathipour and Sedaratian 2013).

Further experiments are therefore suggested to determine the mechanisms of resistance in the selected lines, as well as identifying morphological and physiological factors, which adversely affect development, survival, reproduction and life table parameters of the TSSM.

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غربالگری ۵۵ لاین لوبیا چیتی برای مقاومت نسبت به کنهٔ تارتن دولکه‌ای، *Tetranychus urticae* Koch (Acari: Tetranychidae)

زریر سعیدی

بخش گیاهپزشکی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی چهارمحال و بختیاری، سازمان تحقیقات، آموزش و ترویج کشاورزی، ایران؛ رایانامه: zarirsaeidi@yahoo.com

چکیده

کنهٔ تارتن دولکه‌ای (*Tetranychus urticae* Koch) به عنوان مهم‌ترین آفت لوبیا در مناطق مختلف جهان به شمار می‌رود. در این پژوهش، ۵۵ لاین از بین ژرم‌پلاسم‌های مختلف لوبیا چیتی انتخاب و برای مقاومت نسبت کنهٔ تارتن دولکه‌ای در دو مرحله مورد بررسی قرار گرفتند. در مرحلهٔ نخست، لاین‌ها براساس شدت خسارت وارده به دیسک های برگی (از ۰، بدون خسارت تا ٦، لکه‌های تغذیه‌ای بیش از ۸۰ درصد از سطح برگ)، در پنج گروه قرار گرفتند. ۲۱ لاین بیش‌ترین شاخص خسارت را نشان دادند (LDI = ۵/۳۰ ± ۰/۲۷)، بنابراین، در این مرحله حذف شدند. به جز لاین D_{521}`، که به عنوان شاهد حساس مورد استفاده قرار گرفت. در مرحلهٔ دوم ، ۳٤ لاین با شاخص خسارت کم‌تر از ٤، به همراه لاین 'D$_{521}$' (شاهد حساس) با استفاده از روش دیسک برگی مورد مطالعه قرار گرفتند. نتایج به دست آمده نشان داد که بیش‌ترین میزان تخم‌ریزی در لاین‌های $D_{521}$` (۱/۲۳ ± ۷/۵۲ تخم برای هر کنهٔ ماده در روز) و کم‌ترین میزان تخم‌ریزی در لاین‌های L_1`, $J_{29}$`و L_{19}` (به ترتیب ۰/۲۳± ۱/٤٦ ، ۰/۲٦ ±۱/٦۰ و ۰/۵۹± ۱/٦۹ تخم) مشاهده شد. بیش‌ترین تعداد کنه‌های زنده روی لاین‌های $J_{617}$` و B_{432}` (به ترتیب۰/۱۰ ± ۵ و۰/۲۰ ± ٤/۷۵ عدد کنه از ۵ کنه رهاسازی شده) و کم‌ترین تعداد کنه‌های زنده روی لاین‌های $L_{329}$` و L_{19}` (به ترتیب۰/۲۰ ± ۱/۲ و۰/٤۰ ± ۱/٤) دیده شد. لاین‌ها بر اساس واکنش کنه نسبت به میزبان (میزان تخم‌ریزی و مرگ و میر کنه) و واکنش میزبان نسبت به کنه ( شاخص خسارت) در پنج گروه قرار گرفتند. بر اساس تجزیه خوشه‌ای، لاین‌های $D_{521}$`، J_{633}`، $D_{532}$` و D_{524}` نسبت به کنهٔ تارتن دولکه‌ای حساس بودند در حالی‌که لاین‌های $L_{31}$`، L_{329}`، $L_{321}$`، L_{16}`، $B_{417}$`، B_{425}`، $L_{328}$`، J_{29}`، $J_{67}$`، L_{19}`، $D_3$`، L_{25}`، و $L_1$` نسبت به آفت مقاوم بودند. این لاین‌ها به عنوان منابع مقاومت به کنهٔ تارتن دولکه‌ای در برنامه‌های اصلاح گیاهان می‌توانند مورد استفاده قرار گیرند.

واژگان کلیدی: تجزیه خوشه‌ای؛ آلودگی؛ شاخص خسارت برگ؛ زیست‌سنجی؛ دیسک برگی؛ حساسیت.

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