Genetic Resources Communication

Resistance to the alfalfa weevil in the Iranian collection of *Medicago sativa*

Resistencia al gusano verde en la colección iraní de alfalfa

MOHAMMAD REZA ABBASI

Seed and Plant Improvement Department, Agriculture and Natural Resources Research and Education Center of Khorasan-e Razavi, Agricultural Research, Education & Extension Organization (AREEO), Mashhad, Iran.
kanrrc.areeo.ac.ir

Abstract

The Iranian collection of *Medicago sativa* (alfalfa, 502 accessions) was evaluated under field conditions to identify variation in resistance to the alfalfa weevil (*Hypera postica* Gyllenhal) between accessions over 4 years. Twenty-one accessions were identified as resistant (score 3) to semi-resistant (score 5) based on K-means cluster analysis. These materials were grouped into 10 groups by means of Duncan's Multiple Range Test. Susceptibility to alfalfa weevil was significantly correlated with some of the agro-morphological traits such as plant height ($r = 0.314$, $P<0.01$), regrowth rate ($r = 0.435$, $P<0.01$) and fall dormancy score ($r = 0.284$, $P<0.01$). In general, the resistant germplasm originated from elevated regions at high latitudes, where a co-evolution between the plant and the pest may have taken place. Multiple regression analysis showed a positive linear relationship between susceptibility to the alfalfa weevil and traits such as growth habit, plant height, length and width of the central leaflet and regrowth rate. The resulting bi-plot based on factor analysis ranked accessions for susceptibility to the pest. The identified germplasm should prove useful in alfalfa breeding programs to develop accessions resistant to the alfalfa weevil.

Keywords: Alfalfa landraces, co-evolution, germplasm, *Hypera postica*, pest susceptibility.

Resumen

En Karaj, Irán, se evaluó durante 4 años la colección iraní de 502 accesiones de *Medicago sativa* (alfalfa) en condiciones de campo, para determinar la variación intraespecífica en la resistencia al gusano verde de la alfalfa (*Hypera postica* Gyllenhal). Veintiuna accesiones fueron identificadas como resistentes (puntaje 3) a semi-resistentes (puntaje 5) según el análisis de conglomerados de K-medias. Estos materiales se agruparon en 10 bloques mediante la prueba del rango múltiple de Duncan. La susceptibilidad al gusano verde se correlacionó significativamente con algunos de los parámetros agromorfológicos como la altura de la planta ($r = 0.314$, $P<0.01$), tasa de rebrote ($r = 0.435$, $P<0.01$) y el puntaje de crecimiento otoñal ($r = 0.284$, $P<0.01$). En general, el germoplasma resistente se originó en regiones elevadas en latitudes altas, donde posiblemente ocurrió una co-evolución entre la planta y la plaga. El análisis de regresión múltiple mostró una relación lineal positiva entre la susceptibilidad al gusano verde de la alfalfa y parámetros como el hábito de crecimiento, la altura de la planta, el largo y ancho del folíolo central y la tasa de rebrote. El biplot resultante, basado en el análisis factorial, clasificó las accesiones por susceptibilidad a la plaga. El germoplasma identificado es útil en programas de mejoramiento de alfalfa para desarrollar variedades resistentes al gusano verde.

Palabras clave: Co-evolución, ecotipos, germoplasma, *Hypera postica*, *Medicago sativa*, variabilidad.

Correspondence: M.R. Abbasi, Seed and Plant Improvement Department, Agriculture and Natural Resources Research and Education Center of Khorasan-e Razavi, Agricultural Research, Education & Extension Organization (AREEO), Mashhad, Iran.
Email: m.abbasi@areeo.ac.ir or rabbasim@yahoo.com

Introduction

Alfalfa (*Medicago sativa* L.) is one of the most important forage legumes in the world, and is adapted to a wide range of environments. It is the main forage legume in Iran, being cultivated in about 600,000 ha of mostly irrigated lands (Ahmadi et al. 2015). Alfalfa originated in Vavilov's "Near Eastern Center" Asia Minor, Transcaucasia, Iran and Turkistan (Bolton 1962). In the wild, *M. sativa* and related perennial species are found throughout Eurasia and as far north as Siberia (Hanson et al. 1988). Some parts of Iran are known as the center of diversity for diploid and tetraploid forms of *M. sativa* (Lesins 1976). Studies have shown that the probability of accessing traits, such as resistance to alfalfa weevil, *Hypera postica* (Gyllenhal) (Coleoptera: Curculionidae), is much higher in material collected from the centers of genetic diversity than other parts of the world (Jolivet 1998; Thompson and Cunningham 2002).

The alfalfa weevil is the most destructive pest of alfalfa crops in Iran and originated in the area surrounding the Mediterranean Sea. Essig and Michelbacher (1933) reviewed the history of the pest and concluded that it occurred throughout Europe, western Asia and the northern coast of Africa, plus the Madeira and Canary Islands. In temperate zones, alfalfa weevil can damage up to 100% of the first harvest and 50–100% of the second harvest of alfalfa (Behdad 1996).

In a laboratory study, Campbell and Dudley (1965) reported that a round-stemmed variety of alfalfa, *Medicago sativa* var. *gaetula* Urb., was almost immune to oviposition. From a field study, Norwood et al. (1967) reported that oviposition preference accounted for 26% of the variation in larval feeding damage among alfalfa clones. While Busbice et al. (1967) evaluated 456 alfalfa introductions and found all to be susceptible to the weevil, they noted that plants with thin stems were less preferred for oviposition. In a subsequent study, Busbice et al. (1978) reported that laboratory and greenhouse efforts to breed weevil resistance in alfalfa failed to identify field resistance and concluded that the only effective method of selection for field resistance to the weevil was field selection under natural weevil infestations. These authors suggested that heritability of weevil resistance was moderately high.

Karaj is one of the most important hot-spots for infestation of alfalfa weevil in Iran (Habibi 1976; Mazahery-Laghab and Yazdy-Samadi 1994), so is ideally suited to perform field evaluation of resistance to the weevil. A study on 124 alfalfa varieties showed a significant correlation between weevil damage and some agro-morphological traits (Mazahery-Laghab and Yazdy-Samadi 1994). Although no significant correlation was observed between the level of saponin and alfalfa weevil larval damage (Yazdi-Samadi et al. 2004), Bakhtiyarian and Mazaheri-Laghab (2016) indicated that resistant landraces showed higher levels of saponins in the thin layer chromatograms.

In previous studies, only small alfalfa collections were evaluated for susceptibility to the pest in this country. Hence, the current study presents the results of field evaluation of a comprehensive Iranian alfalfa collection for resistance to alfalfa weevil under natural field infestation in an important hot spot (Karaj, Iran) for the pest.

Materials and Methods

The Iranian collection of *Medicago sativa*, consisting of 502 accessions (Appendix 1) held by National Plant Gene Bank of Iran, was planted in the field at Karaj Experimental Station, Iran (35°52´ N, 50°59´ E; 1,520 masl) in September 2003. Each accession was planted in 2 rows of 1 m length and 50 cm apart with distance between plants within rows of 10 cm. The field was irrigated every 8 days from spring to fall throughout the study. During the following 4 years, susceptibility to alfalfa weevil and agro-morphological traits were evaluated according to IBPGR (1984) descriptors. Growth habit was recorded annually using a scale of: 1 = prostrate, 2 = semi-erect and 3 = erect, at the end of April. Before the second harvest in each year, width and length of the central leaflet at the fourth node of stems were visually scored as: width 1 = very narrow to 9 = very wide, and length as 1 = very short to 9 = very long. Plant height was recorded at 10% flowering for each cutting cycle at which stage each accession was harvested throughout the study. Harvests were performed 4–6 times each year depending on particular accessions. Regrowth rate (cm/day) was determined using plant height at 15 days after each harvest. At the autumn equinox in each year all accessions were harvested, and fall dormancy was recorded as plant height 4 weeks after this harvest, allocating 1 point for every 5 cm of plant height. Plant hairiness was scored as: 1 = hairless, 2 = sparse (base of nearest neighbor further than length of hair) and 3 = dense (base of nearest neighbor closer than length of hair) before the second harvest in the first year. Alfalfa weevil susceptibility (AWS) of accessions was ranked as: 1 = no damage (very resistant), 3 = partial damage to a few terminal leaves (resistant), 5 = partial damage to most leaves (semi-resistant), 7 = severe damage to terminal leaves and partial damage to others (susceptible) and 9 = severe damage to all leaves (very susceptible). The plants were exposed to natural infestation in the field and no

chemicals were applied during the 4-year experiment. Since economic damage to crops occurs from mid-March to early May annually in temperate zones like Karaj, evaluations for weevil damage were carried out at 2 and 4 weeks after the spring equinox. Means of the 2 evaluations in each year were recorded for assessing susceptibility to the pest. Passport data of collection sites were used only in the correlation analysis.

Statistical analyses

Spearman's method was applied to compute correlation coefficients between susceptibility to alfalfa weevil and other traits. Accessions were grouped based on alfalfa weevil susceptibility over the 4-year experiment by K-means cluster analysis to identify 3 categories (resistant, semi-susceptible and susceptible). One-way analysis of variance (ANOVA) was performed to evaluate year and accession effects. Transformed data (square root) were used in the ANOVA. Duncan's Multiple Range Test grouped 21 resistant/semi-resistant accessions and 1 susceptible accession to 7 groups. Multiple regression using the stepwise method was used to estimate the role of agro-morphological traits (as independent variables) on susceptibility to alfalfa weevil (as dependent variable). The factor analysis was performed on the mean of each trait with PCA method and varimax rotation. These analyses were performed by SPSS version 15.

Results

Natural infestations of the pest over the 4-year study were high (Table 1, Figure 1A, Appendix 1). Evaluation of the whole collection (WC, Appendix 1) of 502 accessions of *M. sativa* collected from farmers' fields and wild habitats (Table 1) showed that most accessions were susceptible (Figure 1B). Twenty-one accessions were identified as resistant (score 3) to semi-resistant (score 5) based on K-means cluster analysis and are suggested for use in breeding studies as sources of genes for resistance to alfalfa weevil [called resistant collection (RC), Table 2, Appendix 2]. The means of susceptibility scores from the first to fourth year differed from 8.1 to 8.6 (1 = very resistant to 9 = very susceptible) in the WC and 3.4 to 5.3 in the RC (Table 1). In each year more than 400 accessions were awarded a score of 9 (very susceptible, Figure 1B) indicating the level of natural infestation of the pest over the 4 years. Resistance of individuals varied over time and semi-resistant to semi-susceptible accessions showed fluctuations among years.

Descriptive statistics of agro-morphological traits for RC and WC are shown in Table 1. While most accessions in the WC displayed erect growth habit, 15 of the RC accessions were semi-erect in growth habit, while 2 were erect and 4 were prostrate. RC accessions also showed short and narrow leaflets. Plant height in the RC varied from 20.5 to 49 cm with a mean of 38.1 cm, compared with 20.5 to 97 cm (mean 65.5 cm) in the WC (Table 1).

Table 1. Descriptive statistics for the collection resistant (RC) to alfalfa weevil and the whole collection (WC) of Iranian alfalfa genetic resources based on means of 4-years' data.

Trait[1]	CV		Mean		Mode		Standard deviation		Minimum		Maximum	
	RC	WC	RC	WC	RC	WC	RC	WC	RC	WC	RC	WC
Susceptibility[1] in 1st year	0.25	0.15	5.3	8.2	5	9	1.3	1.2	2	2	7	9
Susceptibility[1] in 2nd year	0.21	0.12	5	8.6	4	9	1.06	1	3	3	6.5	9
Susceptibility[1] in 3rd year	0.60	0.20	3.4	8.1	3	9	2.01	1.65	1	1	8	9
Susceptibility[1] in 4th year	0.27	0.11	4.9	8.6	5	9	1.34	0.99	3	3	7	9
Days between successive cuts	0.14	0.12	38.5	34.1	38	34	5.48	4	28	13	47	47
Fall dormancy score[2]	0.74	0.53	1.2	3.7	1	1	0.89	2	0.1	0.1	3.8	9.9
Growth habit[3]	0.25	0.13	1.9	2.9	2	3	0.48	0.4	1	1	3	3
Plant height (cm)	0.41	0.18	38.1	65.5	29.3	71	16.7	12	20.5	20.5	71	97
Plant hairiness[4]	0.20	0.23	2.5	2.3	2	2	0.51	0.5	2	1	3	3
Regrowth rate (cm/day)	0.56	0.33	0.83	2.07	0.39	1.75	0.46	0.65	0.44	0.25	1.83	3.8
Length of central leaflet[5]	0.47	0.22	4.3	6.9	5	7	2.01	1.5	1	1	9	9
Width of central leaflet[6]	0.39	0.28	3.3	5.7	3	5	1.3	1.6	1	1	5	9
Elevation of collection site (m)	0.24	0.26	1,602	1,523	1,050	1,640	381	401	1,040	18	2,490	2,600

[1]very resistant (1), resistant (3), semi-resistant (5), susceptible (7) and very susceptible (9).
[2]attributing 1 score for every 5 cm of plant height.
[3]prostrate (1), semi-erect (2) and erect (3).
[4]nil (1), sparse (2) and dense (3).
[5]1 (very short) to 9 (very long).
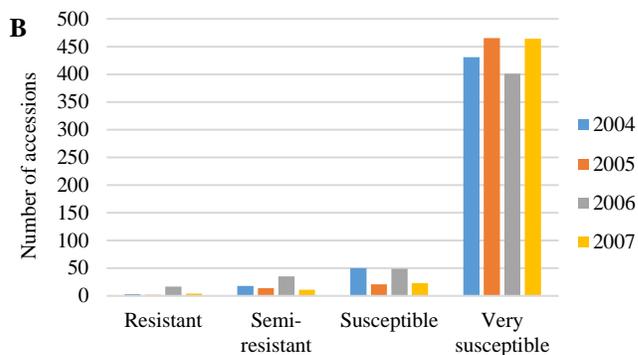[6]1 (very narrow) to 9 (very wide).

Figure 1. Response to alfalfa weevil in the Iranian alfalfa collection (**A**); and the distribution of alfalfa weevil susceptibility in the collection over 4 years (**B**).

Table 2. Results of Duncan's Multiple Range Test for susceptibility to alfalfa weevil; accession number and passport data in the resistant collection (RC; 21 resistant and semi-resistant accessions) produced by K-means cluster analysis.

Plot No.	Accession No.	Alfalfa weevil susceptibility[1]	Local name	Collected from	Latitude (° N)	Longitude (° E)	Elevation (masl)	Province	City
359	51TN0468	3.5cdef	Yonjeh	Wild	ND[2]	ND	1,250	Azarbaijan S	Ahar
14	51TN0572	5.25abcd	Yonjeh	ND	ND	ND	1,750	Azarbaijan S	Tabriz
3	51TN0585	5.25abcd	Yonjeh	Cultivated	30.16	51.59	2,100	Fars	Sepidan
260	51TN0620	6.75a	Gharah_Yonjeh	Wild	37.42	45.12	1,360	Azarbaijan G	Oroumieh
301	51TN0623	4.25bcdef	Gharah_Yonjeh	Wild	37.52	44.58	1,370	Azarbaijan G	Oroumieh
98	51TN0660	5.38abc	ND	Wild	31.47	50.21	ND	Khozestan	Eizeh
97	51TN0668	3.0ef	Yonjeh	Wild	36.34	54.24	2,150	Mazandaran	Gorgan
96	51TN0669	2.75f	Yonjeh	Wild	36.33	54.24	1,840	Mazandaran	Gorgan
95	51TN0672	2.75f	Yonjeh	Wild	36.32	54.25	1,500	Mazandaran	Gorgan
326	51TN0722	4.75abcde	ND	ND	ND	ND	1,040	Khorasan	ND
315	51TN1083	4.38bcdef	Gharah_Yonjeh	Wild	38.13	44.34	1,600	Azarbaijan G	Salmas
45	51TN1223	5.88ab	Yonjeh	ND	ND	ND	1,380	Khorasan	Nishabour
295	51TN1306	5.5 abc	Yonjeh	Wild	30.21	53.18	ND	Fars	Marvdasht
363	51TN1308	5.13abcd	Yonjeh	Wild	30.16	51.59	2,490	Fars	Sepidan
49	51TN1371	5.63ab	Yonjeh-Mar	Wild	ND	ND	1,800	Tehran	Karaj
55	51TN1376	4.5bcdef	Yonjeh	Wild	ND	ND	2,030	Tehran	Damavand
46	51TN1379	5.25abcd	Yonjeh	Cultivated	ND	ND	2,110	Tehran	Damavand
348	51TN1695	5.38abc	ND	Wild	ND	ND	1,600	Khorasan	Nishabour
316	51TN1753	5.13abcd	Yonjeh	Wild	38.01	45.02	1,700	Azarbaijan G	Oroumieh
141	51TN1856	3.25def	ND	Wild	ND	ND	1,800	Hamedan	Nahavand
142	51TN1857	3.25def	ND	Wild	ND	ND	1,800	Hamedan	Nahavand

[1]Means followed by different letters are significantly different (P<0.05).
[2]ND = no data.

RC accessions were generally collected from northern parts of Iran, so had low fall dormancy scores (range 0.1–3.8, mean 1.2). However, the WC showed a larger range (0.1–9.9, mean 3.7) for this trait. In the same manner, re-growth rate and central leaflet width manifested greater ranges in WC than RC. In general, a sparse to dense hairiness was observed in the RC (Table 1).

ANOVA results showed significant differences in RC and WC for susceptibility to the pest over the 4 years (Table 3). Duncan's Multiple Range Test grouped the RC accessions into 10 groups (Table 2). Accessions 51TN0669 and 51TN0672, which originated from northwest Iran, were the most resistant. The resistant to semi-resistant accessions (scores 2 to 5, respectively) were mostly collected from provinces in northern, southwest and central Iran at higher geographical latitudes, which experience a cold-temperate climate (Figure 2).

Susceptibility to the alfalfa weevil showed significant correlation with some agro-morphological traits (Table 4). In WC, susceptibility was significantly and positively correlated with growth habit (r = 0.532, P<0.01), plant height (r = 0.314, P<0.01), regrowth rate (r = 0.435, P<0.01), fall dormancy score (r = 0.284, P<0.01) and width of central leaflet (r = 0.450, P<0.01) (Table 4). There was no significant correlation (P>0.05) between susceptibility to the pest and elevation or longitude, from which the accessions had been collected, but susceptibility was significantly and negatively correlated with latitude of origin (r = -0.296, P<0.01) (Table 4).

Table 3. Results of one-way analysis of variance for alfalfa weevil susceptibility in the resistant and whole collections of Iranian alfalfa.

Source of variation	df	Mean Square	Significance level
Resistant collection			
Accession	20	5.12	0.000
Year	3	15.79	0.000
Error	60	1.47	
Whole collection			
Accession	501	4.13	0.000
Year	3	38.36	0.000
Error	1,503	0.66	
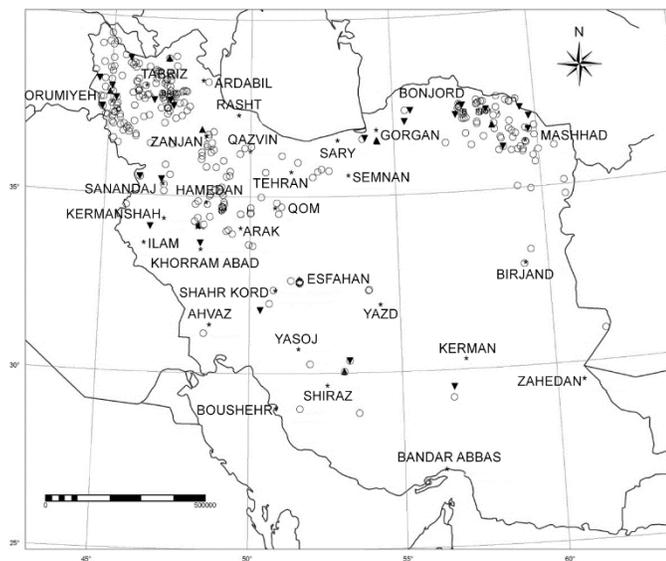
Figure 2. Geographical distribution of the Iranian *Medicago sativa* collection sites and susceptibility of accessions to the alfalfa weevil: susceptible (O), resistant (▲), semi-resistant (▼). ✱: Capital of province.

Multiple stepwise regression analyses revealed a positive linear relationship between alfalfa weevil susceptibility (Y) and traits such as: growth habit (X_1), plant height at flowering (X_2), length of central leaflet (X_3), regrowth rate (X_4) and width of central leaflet (X_5) with $R^2 = 0.32$ as shown in the following Equation 1:

$$Y = 3.55 + 0.367X_1 + 0.125X_2 + 0.132X_3 + 0.185X_4 + 0.123X_5.$$

Factor analysis in the WC showed that 65.2% of the variance was explained by 4 primary factors (Table 5). The first factor, which accounted for 28.1% of the variance, is affected mainly by 3 traits (regrowth rate, fall dormancy score and days between successive harvests).

The second factor explained 21.1% of the variation and was affected by traits such as alfalfa weevil susceptibility, width and length of central leaflet, growth habit and plant height. Distribution of accessions in a bi-plot based on Factors 1 and 2 is shown in Figure 3.

Table 4. Correlation coefficients between agro-morphological traits and susceptibility to the alfalfa weevil based on Spearman's method in both whole (WC) and resistant (RC) alfalfa collections of Iran; data are pooled over 4 years.

Traits	WC	RC
Elevation (masl)	-0.03	0.074
Latitude	-0.296**	-0.341
Longitude	-0.005	-0.339
Days between successive cuts	-0.072	-0.055
Fall dormancy score[1]	0.284**	0.460*
Growth habit[2]	0.532**	0.687**
Plant height (cm)	0.314**	0.495*
Plant hairiness[3]	0.114*	-0.358
Regrowth rate (cm/d)	0.435**	0.532*
Length of central leaflet[4]	0.199**	0.297
Width of central leaflet[5]	0.450**	0.543*

[1]attributing 1 score for every 5 cm of plant height.
[2]prostrate (1), semi-erect (2) and erect (3).
[3]nil (1), sparse (2) and dense (3).
[4]1 (very short) to 9 (very long).
[5]1 (very narrow) to 9 (very wide).

Figure 3. Distribution of alfalfa accessions in terms of alfalfa weevil (AW) susceptibility in the produced bi-plot based on Factors 1 and 2 generated by factor analysis.

Table 5. Results of factor analysis on agronomic traits in the whole collection of Iranian alfalfa.

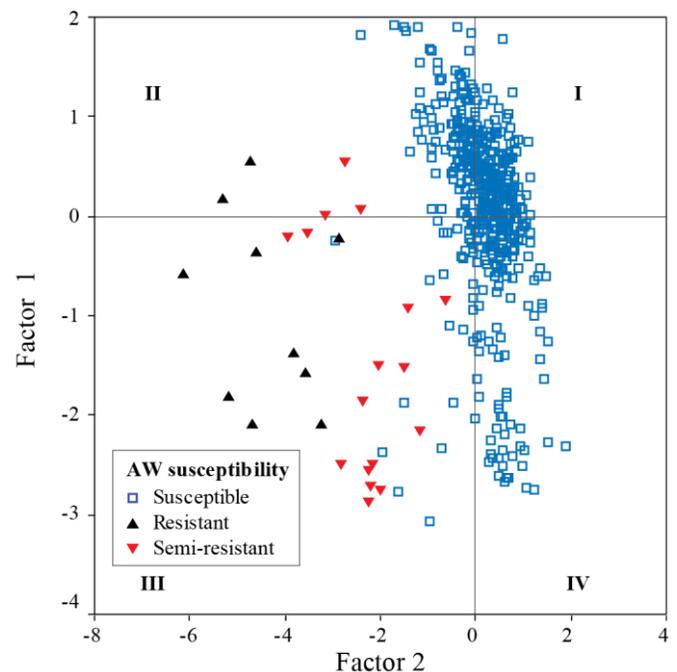|	Factors			
	1	2	3	4
Total eigenvalues	4.78	3.59	1.52	1.20
Percent of variance	28.1	21.1	8.9	7.1
Cumulative percent of variance	28.1	49.2	58.1	65.2
	Eigenvectors			
Alfalfa weevil susceptibility in 3rd year	0.17	0.80	-0.04	-0.07
Alfalfa weevil susceptibility in 4th year	0.34	0.80	-0.13	-0.03
Days between successive cuts	-0.68	-0.04	0.10	0.00
Fall dormancy score[1]	0.59	0.23	0.23	0.42
Growth habit[2]	0.36	0.76	-0.20	-0.03
Plant hairiness[3]	-0.12	0.11	0.21	-0.85
Plant height (cm)	0.38	0.61	-0.31	0.06
Re-growth rate (cm/d)	0.87	0.38	0.15	0.14
Length of central leaflet[4]	-0.02	0.58	0.16	0.42
Width of central leaflet[5]	0.14	0.63	0.29	0.03

[1] attributing 1 score for every 5 cm of plant height.
[2] prostrate (1), semi-erect (2) and erect (3).
[3] nil (1), sparse (2) and dense (3).
[4] 1 (very short) to 9 (very long).
[5] 1 (very narrow) to 9 (very wide).

Discussion

While most of the evaluated accessions were landraces and local varieties, resistant accessions were collected mainly as wild ecotypes from near farmers' fields, on roadsides or within rangelands of mountainous areas in the country. Only 2 landraces collected from farmers' fields showed resistance to the pest (Table 2). Table 1 shows that wild accessions do not rate highly for some evaluated traits such as plant height, re-growth rate and width and length of central leaflets, so they have low potential for forage production. The resistant accessions, including wild accessions 51TN0669 and 51TN0672, were generally collected from northern parts of Iran (Table 2), where cold conditions prevail.

ANOVA results (Table 3) showed that pest damage was different in different years, which could result from increases in pest density in the field from the first year onward that is usually expected. The significant negative correlation between susceptibility to the pest and latitude (r = -0.296, P<0.01) in the WC (Table 4) suggests that resistant material was distributed at higher latitudes, where cold conditions prevail (Figure 2). Some resistant to semi-resistant accessions were collected from Hamedan and Azerbaijan, the origins of the 2 important

cold alfalfa landraces, Hamedani and Gharah-Younjeh (Abbasi et al. 2007), whereas the germplasm collected from warm and subtropical regions lacked resistance to the pest (Figure 2). Earlier studies showed that alfalfa weevil tended to be most prevalent in cold areas, mainly in the cold zones of the mountainous areas (Essig and Michelbacher 1933; Behdad 1996). In such areas, a co-evolution may take place between the pest and the crop, leading to the development of resistant germplasm. The current study indicated that such a phenomenon probably existed between the pest and alfalfa in cold climates (higher latitudes) of the plant's origin. Co-evolution of species is one of the main functions contributing to the Earth's biodiversity. Jolivet (1998) reviewed the inter-relationship between insects and plants and explained the co-evolution phenomenon between an insect and its host plant. According to Thompson and Cunningham (2002), local structure of co-evolutionary selection remains consistent through successive generations. Alfaro et al. (1999), after reviewing literature on genetic resistance in the weevil/spruce system, concluded that there was co-evolution between the weevil and its hosts. Likewise, Mendel (1998) reported that resistance to the Israeli pine bast scale, *Matsucoccus josephi* (Homoptera, Matsu-coccidae), which developed in pines of the subsection *Halepenses*, viz. *Pinus brutia,* is believed to be the result of co-evolution.

Another factor in the susceptibility to the weevil of tropical accessions may be the change in environment (from tropical to temperate conditions). Tropical alfalfa germplasm was collected from southern parts of the country and evaluated in Karaj, where the climate is temperate. Therefore, inherent resistance within these materials may not have been expressed optimally, if the environment was not conducive to natural growth of the germplasm. Abiotic influences like temperature, humidity, solar irradiance, photoperiod, water availability and elevation all could have an impact on the effectiveness of host plant resistance and biological growth of the weevil. The pest does not cause economic damage to the crop in the warm conditions prevailing in southern parts of the country.

The results of correlation analysis were in accordance with some previous reports (Mazahery-Laghab and Yazdy-Samadi 1994; Kakaei et al. 2016). The significant correlation between susceptibility to the pest and plant hairiness (r = 0.114, P<0.05) (Table 4) agrees with reports from earlier studies of a significant negative relationship between hairiness and resistance to the alfalfa weevil (Shade et al. 1975; Bauchan 1998). However, since the correlation coefficient was so low, this trait was not inserted into the final regression equation.

Equation 1 particularly implies that tall erect plants are most susceptible to the pest. Although Busbice et al. (1967) reported that fast growth is an important characteristic contributing to alfalfa weevil resistance, Norwood et al. (1967) showed that laying of pest eggs and larval feeding tended to be least on plants with prostrate growth habit, poor growth and small thin stems. Our results implicitly confirmed these findings.

According to factor analysis and the produced bi-plot, susceptible accessions came together closely towards the center of the bi-plot and semi-resistant materials appeared mainly apart from them in Section III of the bi-plot, while resistant material appeared mostly in Section III, but clearly separated from the semi-resistant accessions (Figure 3). There was a similarity between the results of K-means cluster analysis and the produced bi-plot in identifying the susceptibility of accessions to the alfalfa weevil (Table 2, Figure 3).

This classification of the accessions in the Iranian alfalfa collection under severe natural infestation of alfalfa weevil satisfies the requirements of Busbice et al. (1978) that the only effective method of selection for resistance to the weevil is field selection under natural weevil infestations. Accessions identified as resistant to weevil attack should provide genetic material for use throughout the world in alfalfa breeding studies to develop cultivars resistant to *H. postica* through production of hybrids. The high degree of diversity for most desirable agronomic traits in the resistant collection should ensure that other attributes should not necessarily suffer by using these lines.

Acknowledgments

References

(Note of the editors: All hyperlinks were verified 4 August 2020.)

Abbasi MR; Vaezi S; Hemati F. 2007. Identification of two types of Iranian alfalfa gene pool based on agro-morphological traits. Pakistan Journal of Biological Sciences 10:3314–3321. doi: 10.3923/pjbs.2007.3314.3321

Ahmadi K; Gholizadeh H; Ebadzadeh HR; Hossienpour R; Hatami F; Fazli B; Kazemian A; Rafiei M. 2015. Agricultural Statistics: I. Agronomy crops. Ministry of Agriculture, Tehran, Iran.

Alfaro R; Tomlin E; Borden JH; Lewis K. 1999. Interaction of the white pine weevil (*Pissodes strobi* Peck) and its hosts: Arguments for coevolution. Proceedings of a Conference, Gujan, France, August 31–September 5, 1997. p. 33–39.

Bakhtiyarian S; Mazaheri-Laghab H. 2016. The study of saponin profile in 3 cultivars of alfalfa (*Medicago sativa* L.) expressing different levels of resistance to alfalfa weevil (*Hypera postica* Gyll.) using TLC. Agricultural Biotechnology 7:17–21. (In Persian). magiran.com/p1682099

Bauchan G. 1998. What are annual medics? In: Bouton J; Bauchan GR, eds. Proceedings of the 36th North American Alfalfa Improvement Conference, Bozeman, MT, USA, 2–6 August 1998. p. 6. bit.ly/2OyIh2j

Behdad E. 1996. Pests of field crops in Iran. Yadbood Publishers, Isfahan, Iran.

Bolton JL. 1962. Alfalfa botany, cultivation and utilization. Word Crops Books, Leonard Hill, London, UK.

Busbice T; Campbell W; Bunch LV; Gurgis RY. 1978. Breeding alfalfa cultivars resistant to the alfalfa weevil. Euphytica 27:343–352. doi: 10.1007/BF00043158

Busbice TH; Barnes DK; Hanson CH; Hill RR; Campbell WV; Blickenstaff CC; Newton RC. 1967. Field evaluation of alfalfa introductions for resistance to the alfalfa weevil (*Hypera postica* Gyllenhal). US Department of Agriculture ARS Bulletin, Washington, DC, USA. p. 34–94.

Campbell WV; Dudley JW. 1965. Differences among *Medicago* species in resistance to oviposition by the alfalfa weevil. Journal of Economic Entomology 58:245–248. doi: 10.1093/jee/58.2.245

Essig EO; Michelbacher AE. 1933. The alfalfa weevil. Bulletin of the California Agricultural Experiment Station, No. 567. University of California, Berkeley, CA, USA. bit.ly/3aJPRBx

Habibi J. 1976. Bio-ecological study of *Hypera postica* and test of some pesticide on it in Karaj. Applied Entomology and Phytopathology 44:33–40. (In Persian).

Hanson AA; Barnes DK; Hill Jr RR, eds. 1988. Alfalfa and alfalfa improvement. Agronomy Monograph No. 29. ASA, CSSA, SSSA, Madison, WI, USA. doi: 10.2134/agronmonogr29.c31

IBPGR. 1984. Descriptor list for forage legumes. IBPGR (International Board for Plant Genetic Resources), Rome, Italy. bit.ly/2CG8Kc7

Jolivet P. 1998. Interrelationship between insects and plants. CRC Press, Boca Raton, FL, USA.

Kakaei M; Mazahery-Laghab H; Khanjani M. 2016. Variability of resistance to alfalfa weevil (*Hypera postica* Gyll.) attack in different alfalfa genotypes in Hamedan condition. Plant Production Technology 16:57–67. (In Persian). doi: 10.22084/ppt.2016.1755

Lesins K. 1976. Alfalfa, lucerne. In: Simmonds NW, ed. Evolution of crop plants. Longman, London. p. 165–168.

Mazahery-Laghab H; Yazdy-Samadi B. 1994. Resistance of alfalfa varieties to alfalfa weevil (*Hypera postica* Gyll.). Iranian Journal of Agricultural Sciences 25:11–17.

Mendel Z. 1998. Biogeography of *Matsucoccus josephi* (Homoptera: Matsucoccidae) as related to host resistance in *Pinus brutia* and *Pinus halepensis*. Canadian Journal of Forest Research 28:323–330. doi: 10.1139/x97-211

Norwood BL; Van Denburgh RS; Hanson CH; Blickenstaff CC. 1967. Factors affecting resistance of field-planted alfalfa clones to the alfalfa weevil. Crop Science 7(2):96–99. doi: 10.2135/cropsci1967.0011183X000700020002x

Shade RE; Thompson TE; Campbell WR. 1975. An alfalfa weevil larval resistance mechanism detected in *Medicago*. Journal of Economic Entomology 68(3):399–404. doi: 10.1093/jee/68.3.399

Thompson JN; Cunningham BM. 2002. Geographic structure and dynamics of coevolutionary selection. Nature 417:735–738. doi: 10.1038/nature00810

Yazdi-Samadi B; Bagheri M; Mazahery-Laghab H. 2004. Saponins in alfalfa and their relationships with alfalfa weevil resistance. Proceedings of 4th International Crop Science Congress, Brisbane, Australia. bit.ly/3gv2HWs

Appendix 1. The Iranian collection of *Medicago sativa* and alfalfa weevil susceptibility (AWS) over 4 years.

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
1	51TN0617	3	8.0	8.0	3.0	9.0	8.0	2,100	Fars
2	51TN0616	3	8.0	9.0	3.0	9.0	8.5	2,100	Fars
3	51TN0585	2	5.0	8.0	3.0	5.0	6.5	2,100	Fars
4	51TN0583	3	8.0	7.0	5.0	9.0	7.5		
5	51TN0582	3	8.0	7.0	5.0	9.0	7.5		
6	51TN0581	3	8.0	8.0	5.0	9.0	8.0		
7	51TN0580	3	9.0	9.0	5.0	9.0	9.0		
8	51TN0579	3	9.0	9.0	5.0	9.0	9.0		
9	51TN0578	3	9.0	9.0	8.0	9.0	9.0		
10	51TN0577	3	9.0	9.0	8.0	9.0	9.0		
11	51TN0576	3	9.0	9.0	7.0	9.0	9.0		
12	51TN0575	3	9.0	9.0	8.0	9.0	9.0		
13	51TN0574	3	9.0	9.0	8.0	9.0	9.0		
14	51TN0572	2	5.0	6.0	5.0	5.0	5.5	1,750	Azarbaijan Sharghi
15	51TN0568	3	5.0	9.0	5.0	8.0	7.0	1,850	Azarbaijan Sharghi
16	51TN0565	3	5.0	9.0	6.0	8.0	7.0	1,300	Azarbaijan Sharghi
17	51TN0490	3	7.0	9.0	7.0	9.0	8.0	1,960	Azarbaijan Gharbi
18	51TN0489	3	8.0	9.0	7.0	9.0	8.5	790	Azarbaijan Gharbi
19	51TN0488	3	7.0	9.0	8.0	9.0	8.0	880	Azarbaijan Gharbi
20	51TN0487	3	7.0	9.0	6.0	9.0	8.0	1,060	Azarbaijan Gharbi
21	51TN0486	3	6.0	9.0	6.0	8.0	7.5		Azarbaijan Gharbi
22	51TN0485	3	8.0	9.0	6.0	9.0	8.5	1,160	Azarbaijan Gharbi
23	51TN0484	3	9.0	9.0	5.0	9.0	9.0		Azarbaijan Gharbi
24	51TN0483	3	9.0	9.0	3.0	9.0	9.0	1,325	Azarbaijan Gharbi
25	51TN0482	3	9.0	9.0	5.0	9.0	9.0	1,325	Azarbaijan Gharbi
26	51TN0481	3	9.0	9.0	5.0	9.0	9.0		Azarbaijan Gharbi
27	51TN0480	3	8.0	9.0	5.0	9.0	8.5	1,400	Azarbaijan Gharbi
28	51TN0479	3	8.0	9.0	5.0	9.0	8.5	1,340	Azarbaijan Gharbi
29	51TN0478	3	8.0	9.0	6.0	9.0	8.5	1,390	Azarbaijan Gharbi
30	51TN0477	3	8.0	9.0	7.0	9.0	8.5	1,360	Azarbaijan Gharbi
31	51TN0476	3	8.0	9.0	8.0	9.0	8.5	1,390	Azarbaijan Gharbi
32	51TN0475	3	8.0	9.0	6.0	9.0	8.5	1,360	Azarbaijan Gharbi
33	51TN0474	3	7.0	8.0	7.0	8.0	7.5	1,460	Azarbaijan Gharbi
34	51TN0473	3	7.0	9.0	6.0	8.0	8.0	1,550	Azarbaijan Gharbi
35	51TN0472	3	7.0	9.0	5.0	9.0	8.0	1,370	Azarbaijan Gharbi
36	51TN0471	3	7.0	9.0	6.0	9.0	8.0	1,460	Azarbaijan Gharbi
37	51TN0470	3	8.0	9.0	5.0	9.0	8.5	1,450	Azarbaijan Gharbi
38	51TN0467	3	7.0	9.0	5.0	9.0	8.0	1,700	Azarbaijan Sharghi
39	51TN0464	3	7.0	9.0	5.0	8.0	8.0	1,740	Azarbaijan Sharghi
40	51TN0463	3	7.0	9.0	6.0	7.0	8.0	2,060	Azarbaijan Sharghi
41	51TN1238	3	7.0	9.0	8.0	9.0	8.0	1,140	Khorasan
42	51TN1218	3	7.0	9.0	9.0	8.0	8.0	1,300	Khorasan
43	51TN1208	3	9.0	9.0	8.0	9.0	9.0	1,120	Khorasan
44	51TN1263	3	8.0	9.0	7.0	8.0	8.5	1,300	Khorasan
45	51TN1223	2	7.0	6.5	5.0	5.0	6.8	1,380	Khorasan
46	51TN1379	2	5.0	8.0	3.0	5.0	6.5	2,110	Tehran
47	51TN1368	3	8.0	9.0	3.0	7.0	8.5	1,280	Zanjan
48	51TN1382	3	8.0	9.0	5.0	7.0	8.5	2,200	Tehran
49	51TN1371	2	8.0	4.5	3.0	7.0	6.3	1,800	Tehran
50	51TN1383	3	8.0	9.0	5.0	6.0	8.5	1,700	Zanjan
51	51TN1384	3	8.0	9.0	5.0	6.0	8.5	1,300	Zanjan
52	51TN1380	3	8.0	9.0	5.0	6.0	8.5	2,600	Tehran
54	51TN1389	3	9.0	9.0	5.0	9.0	9.0	680	Markazi
55	51TN1376	2	5.0	4.0	5.0	4.0	4.5	2,030	Tehran
56	51TN1369	3	8.0	9.0	7.0	9.0	8.5	1,200	Zanjan
57	51TN1386	3	9.0	9.0	8.0	9.0	9.0	1,320	Tehran
58	51TN1363	3	8.0	9.0	7.0	9.0	8.5	1,200	Tehran
59	51TN1374	3	8.0	9.0	7.0	8.0	8.5	2,220	Tehran
60	51TN1366	3	8.0	9.0	8.0	8.0	8.5	1,900	Zanjan
61	51TN1367	3	8.0	9.0	9.0	9.0	8.5	1,800	Zanjan
62	51TN1378	3	9.0	9.0	8.0	9.0	9.0	1,520	Tehran
63	51TN1390	3	9.0	9.0	8.0	9.0	9.0	700	Markazi
64	51TN1156	3	8.0	9.0	8.0	9.0	8.5		Zanjan
65	51TN1254	3	8.0	9.0	8.0	9.0	8.5	1,500	Khorasan
66	51TN1249	3	8.0	9.0	9.0	9.0	8.5	350	Khorasan
67	51TN1248	3	8.0	9.0	9.0	9.0	8.5	800	Khorasan
68	51TN1246	3	8.0	9.0	9.0	9.0	8.5	1,460	Khorasan

Continued

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
69	51TN1133	3	9.0	9.0	9.0	9.0	9.0		
70	51TN1359	3	9.0	9.0	9.0	9.0	9.0	2,000	Chaharmahal Bakhtiari
71	51TN1538	3	9.0	9.0	9.0	9.0	9.0		
72	51TN1537	3	9.0	9.0	9.0	9.0	9.0		
73	51TN1535	3	9.0	9.0	9.0	9.0	9.0		
74	51TN1531	3	9.0	9.0	9.0	9.0	9.0		
75	51TN1454	3	8.0	9.0	9.0	9.0	8.5	1,700	Azarbaijan Sharghi
76	51TN1031	3	8.0	8.0	9.0	8.0	8.0	1,050	Kordestan
77	51TN1120	3	9.0	9.0	9.0	9.0	9.0		
78	51TN1118	3	9.0	9.0	9.0	9.0	9.0		
79	51TN1154	3	9.0	9.0	9.0	9.0	9.0	2,150	Markazi
80	51TN1135	3	9.0	9.0	7.0	8.0	9.0	1,820	Markazi
81	51TN1035	3	8.0	9.0	8.0	9.0	8.5	1,050	Kordestan
82	51TN1034	3	8.0	9.0	9.0	9.0	8.5	1,050	Kordestan
83	51TN1107	3	9.0	9.0	9.0	9.0	9.0		
84	51TN0728	3	9.0	9.0	9.0	9.0	9.0		
85	51TN0727	3	9.0	8.0	9.0	9.0	8.5		
86	51TN0725	3	9.0	9.0	9.0	9.0	9.0	985	Khorasan
87	51TN0719	3	8.0	8.5	9.0	8.0	8.3	1,300	Khorasan
88	51TN0718	3	9.0	9.0	8.0	9.0	9.0	580	Khorasan
89	51TN0700	3	9.0	8.0	9.0	7.0	8.5	1,100	Khorasan
90	51TN0699	3	9.0	8.5	9.0	9.0	8.8	1,200	Khorasan
92	51TN0679	3	9.0	9.0	8.0	9.0	9.0	1,345	Khorasan
93	51TN0678	3	9.0	9.0	9.0	9.0	9.0	1,345	Khorasan
94	51TN0677	3	9.0	9.0	8.0	8.0	9.0	1,345	Khorasan
95	51TN0672	1	2.0	3.0	1.0	4.0	3.0	1,500	Mazandaran
96	51TN0669	1	3.0	3.0	1.0	4.0	3.0	1,840	Mazandaran
97	51TN0668	1	3.0	4.0	1.0	4.0	3.5	2,150	Mazandaran
98	51TN0660	2	5.0	4.5	5.0	7.0	4.8		Khozestan
99	51TN0658	3	9.0	6.0	5.0	9.0	7.5	18	Khozestan
101	51TN0645	3	8.0	8.0	5.0	8.0	8.0	1,950	Kordestan
102	51TN0644	3	8.0	9.0	5.0	9.0	8.5	1,400	Kordestan
103	51TN0643	3	9.0	9.0	6.0	9.0	5.5	1,550	Kordestan
104	51TN0634	3	5.0	6.5	6.0	9.0	5.8	2,100	Azarbaijan Gharbi
105	51TN0630	3	6.0	8.0	7.0	9.0	7.0	1,600	Azarbaijan Gharbi
106	51TN0629	3	6.0	8.0	8.0	8.0	7.0	1,320	Azarbaijan Gharbi
107	51TN1838	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
108	51TN1837	3	9.0	9.0	9.0	8.0	9.0	1,630	Hamedan
109	51TN1827	3	9.0	9.0	9.0	9.0	9.0		Hamedan
110	51TN1840	3	9.0	9.0	8.0	9.0	9.0		Hamedan
111	51TN1770	3	9.0	9.0	9.0	9.0	9.0	1,669	Hamedan
112	51TN1768	3	9.0	9.0	9.0	9.0	9.0		Hamedan
113	51TN1832	3	9.0	9.0	9.0	9.0	9.0	1,669	Hamedan
114	51TN1834	3	9.0	9.0	9.0	9.0	9.0		Hamedan
115	51TN1833	3	8.0	9.0	9.0	8.0	8.5		Hamedan
116	51TN1789	3	8.0	9.0	9.0	9.0	8.5	1,640	Hamedan
117	51TN1831	3	8.0	9.0	9.0	9.0	8.5	1,640	Hamedan
118	51TN1823	3	9.0	9.0	9.0	9.0	9.0	1,669	Hamedan
119	51TN1776	3	9.0	9.0	9.0	9.0	9.0	1,590	Hamedan
120	51TN1769	3	8.0	9.0	9.0	9.0	8.5		Hamedan
121	51TN1788	3	9.0	9.0	8.0	9.0	9.0	1,640	Hamedan
122	51TN1800	3	9.0	9.0	9.0	9.0	9.0	1,661	Hamedan
123	51TN1826	3	9.0	9.0	9.0	9.0	9.0	1,630	Hamedan
124	51TN1794	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
125	51TN1244	3	9.0	9.0	9.0	9.0	9.0	1,100	Khorasan
126	51TN1234	3	9.0	9.0	9.0	9.0	9.0	840	Khorasan
127	51TN1243	3	9.0	9.0	9.0	9.0	9.0	1,100	Khorasan
128	51TN1252	3	9.0	9.0	9.0	9.0	9.0	880	Khorasan
129	51TN1247	3	9.0	9.0	9.0	9.0	9.0	1,500	Khorasan
130	51TN1237	3	9.0	9.0	9.0	9.0	9.0	1,160	Khorasan
131	51TN1230	2	7.0	9.0	9.0	7.0	8.0	1,020	Khorasan
132	51TN1260	3	8.0	9.0	9.0	9.0	8.5	1,320	Khorasan
133	51TN1262	3	8.0	9.0	8.0	9.0	8.5	1,400	Khorasan
134	51TN1224	2	6.0	6.0	8.0	6.0	6.0	1,620	Khorasan
135	51TN1766	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
136	51TN1809	3	9.0	9.0	9.0	9.0	9.0		Hamedan
137	51TN1777	3	9.0	9.0	9.0	9.0	9.0	1,700	Hamedan
138	51TN1783	3	9.0	9.0	9.0	8.0	9.0	1,660	Hamedan
139	51TN1804	3	9.0	9.0	9.0	9.0	9.0	1,665	Hamedan

Continued

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
140	51TN1857	3	8.0	9.0	9.0	9.0	8.5	1,800	Hamedan
141	51TN1856	2	5.0	4.0	1.0	3.0	4.5	1,800	Hamedan
142	51TN1857	2	5.0	4.0	1.0	3.0	4.5	1,800	Hamedan
143	51TN1814	3	9.0	9.0	8.0	9.0	9.0	1,640	Hamedan
144	51TN1818	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
145	51TN1780	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
146	51TN1787	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
147	51TN1791	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
148	51TN1796	3	9.0	9.0	8.0	8.0	9.0		Hamedan
149	51TN1816	3	9.0	9.0	8.0	8.0	9.0	1,640	Hamedan
150	51TN1206	3	9.0	9.0	7.0	8.0	9.0	940	Khorasan
151	51TN1774	3	9.0	9.0	7.0	9.0	9.0	1,640	Hamedan
152	51TN1812	3	9.0	9.0	9.0	9.0	9.0		Hamedan
153	51TN1829	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
154	51TN1773	3	9.0	9.0	9.0	9.0	9.0	1,669	Hamedan
155	51TN1820	3	9.0	9.0	9.0	9.0	9.0	1,630	Hamedan
156	51TN1813	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
157	51TN1784	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
158	51TN1795	3	9.0	9.0	8.0	9.0	9.0	1,640	Hamedan
159	51TN1781	3	9.0	9.0	8.0	9.0	9.0		Hamedan
160	51TN1817	3	9.0	9.0	9.0	9.0	9.0	1,630	Hamedan
161	51TN1825	3	9.0	9.0	9.0	9.0	9.0	1,648	Hamedan
162	51TN1836	3	9.0	9.0	9.0	9.0	9.0		Hamedan
163	51TN1565	3	9.0	9.0	9.0	9.0	9.0	1,950	Markazi
164	51TN1567	3	9.0	9.0	9.0	9.0	9.0	1,002	Markazi
165	51TN1564	3	9.0	9.0	9.0	9.0	9.0	1,860	Markazi
166	51TN1563	3	9.0	9.0	9.0	9.0	9.0	1,800	Markazi
168	51TN0720	3	9.0	9.0	8.0	9.0	9.0	1,600	Khorasan
169	51TN0716	3	7.0	8.5	8.0	9.0	7.8	1,380	Khorasan
170	51TN0714	3	7.0	9.0	9.0	9.0	8.0	1,820	Khorasan
171	51TN0713	3	8.0	9.0	9.0	9.0	8.5	1,200	Khorasan
172	51TN0711	3	7.0	9.0	9.0	9.0	8.0	480	Khorasan
173	51TN0712	2	6.0	6.5	9.0	6.0	6.3	1,120	Khorasan
174	51TN1566	3	9.0	9.0	9.0	9.0	9.0		Markazi
175	51TN1598	3	9.0	9.0	9.0	9.0	9.0	1,590	Esfahan
176	51TN1599	3	9.0	9.0	9.0	9.0	9.0	1,350	Esfahan
177	51TN1602	3	9.0	9.0	9.0	9.0	9.0	1,560	Esfahan
178	51TN1600	3	9.0	9.0	9.0	9.0	9.0	1,580	Esfahan
179	51TN1604	3	9.0	9.0	8.0	9.0	9.0	1,565	Esfahan
180	51TN1597	3	9.0	9.0	8.0	9.0	9.0	1,350	Esfahan
181	51TN1601	3	9.0	9.0	9.0	9.0	9.0	1,595	Esfahan
182	51TN1605	3	9.0	9.0	9.0	9.0	9.0	1,560	Esfahan
183	51TN1603	3	9.0	9.0	8.0	9.0	9.0	1,580	Esfahan
184	51TN1525	3	9.0	9.0	9.0	9.0	9.0	1,100	Yazd
185	51TN1529	3	9.0	9.0	9.0	9.0	9.0	1,100	Yazd
186	51TN1528	3	9.0	9.0	9.0	9.0	9.0	1,200	Yazd
187	51TN1527	3	9.0	9.0	8.0	9.0	9.0	1,100	Yazd
188	51TN1772	3	9.0	9.0	8.0	8.0	9.0	1,660	Hamedan
189	51TN0679-1	3	9.0	9.0	9.0	9.0	9.0	1,345	Khorasan
190	51TN0678-1	3	9.0	9.0	9.0	9.0	9.0	1,345	Khorasan
191	51TN0677-1	3	9.0	9.0	9.0	9.0	9.0	1,345	Khorasan
192	51TN0680	3	9.0	9.0	9.0	9.0	9.0		
193	51TN0675	3	9.0	9.0	9.0	9.0	9.0	1,345	Khorasan
194	51TN0676	3	9.0	9.0	8.0	9.0	9.0	1,345	Khorasan
195	51TN1798	3	9.0	9.0	8.0	9.0	9.0	1,661	Hamedan
196	51TN1828	3	9.0	9.0	9.0	9.0	9.0		Hamedan
197	51TN1802	3	9.0	9.0	7.0	9.0	9.0	1,640	Hamedan
198	51TN1786	3	9.0	9.0	7.0	9.0	9.0	1,640	Hamedan
199	51TN1815	3	9.0	9.0	7.0	9.0	9.0	1,640	Hamedan
200	51TN1830	3	9.0	8.5	6.0	9.0	8.8	1,630	Hamedan
201	51TN1793	3	9.0	6.0	4.0	9.0	7.5	1,640	Hamedan
202	51TN1790	3	9.0	9.0	7.0	9.0	9.0		Hamedan
203	51TN1785	3	9.0	9.0	7.0	9.0	9.0	1,640	Hamedan
204	51TN1771	3	9.0	8.0	7.0	9.0	8.5		Hamedan
205	51TN1779	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
206	51TN1808	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
207	51TN1807	3	9.0	9.0	9.0	9.0	9.0	1,680	Hamedan
208	51TN1821	3	9.0	9.0	9.0	9.0	9.0		Hamedan
209	51TN1803	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan

Continued

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
210	51TN1805	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
211	51TN1839	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
212	51TN1806	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
213	51TN1792	3	8.0	9.0	9.0	9.0	8.5	1,648	Hamedan
214	51TN1797	3	8.0	9.0	9.0	9.0	8.5		Hamedan
215	51TN1775	3	9.0	9.0	9.0	9.0	9.0	1,640	Hamedan
216	51TN1819	3	9.0	9.0	9.0	9.0	9.0	1,648	Hamedan
217	51TN1801	3	9.0	9.0	9.0	9.0	9.0	1,669	Hamedan
218	51TN1810	3	9.0	9.0	9.0	9.0	9.0	1,630	Hamedan
219	51TN1811	3	9.0	9.0	9.0	9.0	9.0		Hamedan
220	51TN1822	3	9.0	9.0	8.0	9.0	9.0		Hamedan
221	51TN1824	3	9.0	9.0	6.0	9.0	9.0	1,630	Hamedan
222	51TN1799	3	9.0	9.0	8.0	9.0	9.0	1,640	Hamedan
223	51TN1778	3	9.0	9.0	9.0	9.0	9.0	1,665	Hamedan
224	51TN1767	3	9.0	9.0	5.0	9.0	9.0		Hamedan
225	51TN1782	3	9.0	9.0	5.0	9.0	9.0	1,669	Hamedan
226	51TN1125	3	9.0	9.0	9.0	9.0	9.0		
227	51TN1131	3	9.0	9.0	9.0	9.0	9.0		
228	51TN1124	3	9.0	9.0	9.0	9.0	9.0		
229	51TN1134	3	9.0	9.0	9.0	9.0	9.0		
230	51TN1360	3	9.0	9.0	9.0	9.0	9.0	1,800	Chaharmahal Bakhtiari
231	51TN1119	3	9.0	9.0	9.0	9.0	9.0		
232	51TN1126	3	9.0	9.0	9.0	9.0	9.0		
233	51TN1129-1	3	9.0	9.0	8.0	9.0	9.0		
234	51TN1128	3	9.0	9.0	9.0	9.0	9.0		
235	51TN1186	3	9.0	9.0	9.0	9.0	9.0	730	Boshehr
236	51TN1606	3	7.0	8.0	8.0	9.0	7.5	2,100	Kordestan
237	51TN1578	3	8.0	9.0	9.0	9.0	8.5	1,890	Azarbaijan Sharghi
238	51TN1132	3	9.0	9.0	9.0	9.0	9.0		
239	51TN1122	3	9.0	9.0	9.0	8.0	9.0		
240	51TN1121	3	9.0	9.0	9.0	9.0	9.0		
241	51TN1740	3	9.0	9.0	9.0	9.0	9.0		
242	51TN1739	3	9.0	9.0	9.0	9.0	9.0		
243	51TN1391	3	9.0	9.0	8.0	8.0	9.0	2,180	Kohkiloyeh Boeyahmad
244	51TN1392	3	9.0	9.0	9.0	8.0	9.0	1,600	Kohkiloyeh Boeyahmad
245	51TN1393	3	9.0	9.0	9.0	9.0	9.0	2,180	Kohkiloyeh Boeyahmad
246	51TN1526	3	9.0	9.0	9.0	9.0	9.0	1,100	Yazd
247	51TN1533	3	9.0	9.0	9.0	9.0	9.0		
248	51TN1536	3	9.0	9.0	9.0	9.0	9.0		
249	51TN1532	3	9.0	9.0	9.0	9.0	9.0		
250	51TN1539	3	9.0	8.0	8.0	9.0	8.5		
251	51TN1534	2	9.0	9.0	9.0	9.0	9.0		
252	51TN1530	3	9.0	9.0	9.0	9.0	9.0		
253	51TN1568	3	9.0	9.0	8.0	9.0	9.0	1,005	Markazi
254	51TN1562	3	8.0	9.0	9.0	9.0	8.5	1,050	Markazi
255	51TN1253	3	7.0	9.0	9.0	8.0	8.0	1,440	Khorasan
256	51TN0625	3	7.0	8.5	8.0	9.0	7.8	1,650	Azarbaijan Gharbi
257	51TN0621	3	7.0	8.5	9.0	7.0	7.8	2,000	Azarbaijan Gharbi
258	51TN0637	3	8.0	9.0	9.0	9.0	8.5	1,650	Azarbaijan Gharbi
260	51TN0620	1	4.0	6.0	5.0	6.0	5.0	1,360	Azarbaijan Gharbi
260-1	51TN0620-1	3	8.0	8.0	4.0	6.0	8.0	1,360	Azarbaijan Gharbi
261	51TN0626	2	7.0	7.0	7.0	8.0	7.0	1,330	Azarbaijan Gharbi
262	51TN0624	3	9.0	9.0	9.0	8.0	9.0	1,795	Azarbaijan Gharbi
263	51TN0634-1	3	9.0	8.0	9.0	9.0	8.5	2,100	Azarbaijan Gharbi
264	51TN0631	3	9.0	9.0	8.0	9.0	9.0	2,020	Azarbaijan Gharbi
265	51TN0622	3	8.0	9.0	9.0	8.0	8.5	1,350	Azarbaijan Gharbi
266	51TN0632	2	7.0	7.0	9.0	7.0	7.0	2,400	Azarbaijan Gharbi
267	51TN0641	3	9.0	9.0	9.0	9.0	9.0	1,360	Azarbaijan Gharbi
268	51TN0636	3	9.0	9.0	8.0	9.0	9.0	1,650	Azarbaijan Gharbi
269	51TN0628	3	9.0	9.0	9.0	9.0	9.0	1,320	Azarbaijan Gharbi
270	51TN0629-1	3	9.0	9.0	9.0	9.0	9.0	1,320	Azarbaijan Gharbi
271	51TN0640	3	9.0	9.0	9.0	9.0	9.0	1,370	Azarbaijan Gharbi
272	51TN0630-1	3	8.0	9.0	9.0	9.0	8.5	1,600	Azarbaijan Gharbi
273	51TN0639	3	5.0	7.5	8.0	9.0	6.3	1,750	Azarbaijan Gharbi
274	51TN0627	3	8.0	9.0	9.0	9.0	8.5	1,330	Azarbaijan Gharbi
275	51TN0633	3	8.0	9.0	9.0	9.0	8.5	1,340	Azarbaijan Gharbi
276	51TN0635	3	9.0	9.0	6.0	9.0	9.0	1,375	Azarbaijan Gharbi
277	51TN1595	3	9.0	9.0	9.0	9.0	9.0		
278	51TN1582	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi

Continued

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
279	51TN1583	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
280	51TN1585	3	9.0	9.0	8.0	9.0	9.0	1,890	Azarbaijan Sharghi
281	51TN1592	3	8.0	9.0	8.0	9.0	8.5		
282	51TN1594	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
283	51TN1587	3	9.0	9.0	9.0	8.0	9.0	1,890	Azarbaijan Sharghi
284	51TN1580	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
285	51TN1593	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
286	51TN1591	3	9.0	9.0	8.0	9.0	9.0	1,890	Azarbaijan Sharghi
287	51TN1584	3	8.0	9.0	9.0	9.0	8.5	1,890	Azarbaijan Sharghi
288	51TN1577	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
289	51TN1590	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
290	51TN1105	3	9.0	9.0	9.0	9.0	9.0		
291	51TN1110	3	9.0	9.0	9.0	9.0	9.0		
292	51TN1108	3	9.0	9.0	9.0	9.0	9.0		
293	51TN1109	3	9.0	9.0	9.0	9.0	9.0		
294	51TN1137	3	9.0	8.5	9.0	9.0	8.8	2,150	Markazi
295	51TN1306	2	6.0	5.0	8.0	6.0	5.5		Fars
296	51TN1111	2	9.0	8.0	8.0	9.0	8.5		
297	51TN1764	3	9.0	8.5	8.0	9.0	8.8		Zanjan
298	51TN1152	3	8.0	9.0	7.0	9.0	8.5	1,830	Markazi
299	51TN1138	3	9.0	8.5	6.0	9.0	8.8	1,750	Markazi
300	51TN1582-1	3	9.0	9.0	5.0	9.0	9.0	1,890	Azarbaijan Sharghi
301	51TN0623	2	5.0	4.0	5.0	3.0	4.5	1,370	Azarbaijan Gharbi
302	51TN1754	3	8.0		6.0	9.0	8.0	1,330	Azarbaijan Gharbi
303	51TN1160	3	8.0	8.0	7.0	9.0	8.0		Zanjan
304	51TN1156-1	3	9.0	8.0	9.0	9.0	8.5		Zanjan
305	51TN1756	3	9.0	8.0	9.0	9.0	8.5	1,650	Azarbaijan Gharbi
306	51TN1051	3	9.0	9.0	8.0	9.0	9.0	1,345	Azarbaijan Gharbi
307	51TN1086	3	9.0	9.0	9.0	9.0	9.0	1,100	Azarbaijan Gharbi
308	51TN1082	2	8.0	6.0	8.0	6.0	7.0	1,850	Azarbaijan Gharbi
309	51TN1085	3	9.0	9.0	8.0	9.0	9.0	1,650	Azarbaijan Gharbi
310	51TN1157	3	8.0	9.0	8.0	9.0	8.5		Zanjan
311	51TN1158	3	7.0	9.0	9.0	9.0	8.0		Zanjan
312	51TN1159	3	8.0	9.0	9.0	9.0	8.5		Zanjan
313	51TN1163	3	8.0	9.0	9.0	9.0	8.5		Zanjan
314	51TN1164	3	9.0	9.0	9.0	9.0	9.0		Zanjan
315	51TN1083	2	6.0	4.5	2.0	5.0	5.3	1,600	Azarbaijan Gharbi
316	51TN1753	2	6.0	5.5	3.0	6.0	5.8	1,700	Azarbaijan Gharbi
317	51TN1162	3	9.0	9.0	9.0	9.0	9.0		Zanjan
318	51TN1161	3	9.0	9.0	9.0	9.0	9.0		Zanjan
319	51TN1165	3	8.0	8.0	9.0	9.0	8.0		Zanjan
320	51TN1692	3	6.0	9.0	6.0	9.0	7.5	1,300	Khorasan
321	51TN0994	2	8.0	9.0	6.0	7.0	8.5	1,900	Azarbaijan Sharghi
322	51TN0988	3	8.0	9.0	7.0	9.0	8.5	1,570	Azarbaijan Sharghi
323	51TN0996	3	9.0	9.0	7.0	9.0	9.0	1,450	Azarbaijan Sharghi
325	51TN0724	2	6.0		3.0	8.0	6.0	550	Khorasan
326	51TN0722	2	5.0	5.0	2.0	7.0	5.0	1,040	Khorasan
327	51TN0717	3	7.0	9.0	7.0	8.0	8.0	1,300	Khorasan
328	51TN0710	3	7.0	9.0	9.0	8.0	8.0	1,080	Khorasan
328-1	51TN0710-1	3	7.0	9.0	9.0	8.0	8.0	1,080	Khorasan
329	51TN1696	3	7.0	8.0	9.0	9.0	7.5	1,200	Khorasan
330	51TN1700	3	9.0	9.0	9.0	9.0	9.0	1,240	Khorasan
331	51TN1707	2	6.0	6.0	8.0	7.0	6.0	1,460	Khorasan
332	51TN1704	3	9.0	9.0	9.0	9.0	9.0	1,320	Khorasan
333	51TN1685	3	8.0	9.0	9.0	9.0	8.5	1,180	Khorasan
334	51TN1711	3	8.0	9.0	8.0	8.0	8.5	1,120	Khorasan
335	51TN1686	3	9.0	9.0	9.0	9.0	9.0	1,440	Khorasan
336	51TN1699	2	7.0	9.0	9.0	9.0	8.0	1,200	Khorasan
337	51TN1716	3	9.0	9.0	8.0	9.0	9.0	1,340	Khorasan
338	51TN1709	3	9.0	9.0	9.0	9.0	9.0	1,440	Khorasan
339	51TN1718	3	9.0	9.0	9.0	9.0	9.0	1,360	Khorasan
340	51TN1678	3	9.0	9.0	9.0	9.0	9.0	1,890	Khorasan
341	51TN1684	3	9.0	9.0	9.0	9.0	9.0	1,160	Khorasan
342	51TN1690	3	9.0	9.0	9.0	9.0	9.0	1,100	Khorasan
343	51TN1720	3	9.0	9.0	9.0	9.0	9.0	1,420	Khorasan
344	51TN1698	3	9.0	9.0	8.0	9.0	9.0	1,200	Khorasan
345	51TN1637	3	7.0	9.0	8.0	9.0	8.0		
346	51TN1713	3	9.0	9.0	8.0	9.0	9.0	1,540	Khorasan
347	51TN1703	3	9.0	9.0	8.0	9.0	9.0	1,390	Khorasan

Continued

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
348	51TN1695	2	4.0	4.5	7.0	6.0	4.3	1,600	Khorasan
349	51TN1719	3	9.0	9.0	8.0	8.0	9.0	1,400	Khorasan
350	51TN1726	3	9.0	9.0	8.0	8.0	9.0	1,050	Khorasan
351	51TN1725	3	8.0	9.0	8.0	8.0	8.5	960	Khorasan
352	51TN1722	3	9.0	9.0	8.0	9.0	9.0	1,700	Khorasan
353	51TN1728	3	9.0	9.0	9.0	9.0	9.0	1,160	Khorasan
354	51TN1724	3	9.0	9.0	9.0	9.0	9.0	1,200	Khorasan
355	51TN0461	3	8.0	9.0	9.0	8.0	8.5	1,980	Azarbaijan Sharghi
356	51TN0464-1	3	9.0	8.5	8.0	9.0	8.8	1,740	Azarbaijan Sharghi
357	51TN0462	3	9.0	8.0	9.0	9.0	8.5	2,100	Azarbaijan Sharghi
358	51TN0488	3	9.0	9.0	9.0	9.0	9.0	880	Azarbaijan Gharbi
359	51TN0468	2	4.0	4.0	3.0	3.0	4.0	1,250	Azarbaijan Sharghi
360	51TN0466	3	8.0	9.0	9.0	9.0	8.5	1,500	Azarbaijan Sharghi
361	51TN0489-1	3	9.0	9.0	9.0	9.0	9.0	790	Azarbaijan Gharbi
363	51TN1308	2	7.0	5.5	3.0	5.0	6.3	2,490	Fars
364	51TN1313	2	9.0	4.0	3.0		6.5	1,920	Fars
365	51TN1306-1	2	7.0	5.5	6.0	5.0	6.3		Fars
366	51TN1759	3	9.0	9.0	9.0	9.0	9.0	1,810	Zanjan
367	51TN1032	2	7.0	5.0	9.0	8.0	6.0	1,050	Kordestan
367-1	51TN1032-1	3	7.0	6.0	9.0	9.0	6.5	1,050	Kordestan
368	51TN1572	3	9.0	9.0	9.0	9.0	9.0	,	Kerman
369	51TN1761	3	9.0	9.0	9.0	9.0	9.0		Zanjan
370	51TN1757	3	8.0	9.0	9.0	9.0	8.5	2,040	Zanjan
371	51TN1762	3	9.0	9.0	9.0	9.0	9.0		Zanjan
372	51TN1765	3	9.0	8.5	9.0	9.0	8.8		Zanjan
373	51TN1760	3	9.0	9.0	9.0	9.0	9.0	1,770	Zanjan
374	51TN1758	3	9.0	9.0	9.0	9.0	9.0		Zanjan
375	51TN1449	3	9.0	9.0	9.0	9.0	9.0		Azarbaijan Sharghi
376	51TN1437	3	8.0	8.0	9.0	9.0	8.0	1,700	Azarbaijan Sharghi
377	51TN1431	3	8.0	8.5	9.0	9.0	8.3	1,850	Azarbaijan Sharghi
378	51TN1495	3	9.0	8.0	9.0	9.0	8.5	1,850	Azarbaijan Sharghi
379	51TN1442	3	9.0	9.0	9.0	9.0	9.0	1,730	Azarbaijan Sharghi
380	51TN1517	3	9.0	9.0	9.0	9.0	9.0	1,400	Azarbaijan Sharghi
381	51TN1443	3	8.0	9.0	9.0	9.0	8.5	1,700	Azarbaijan Sharghi
382	51TN1465	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
383	51TN1459	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
384	51TN1463	3	9.0	9.0	9.0	9.0	9.0	1,500	Azarbaijan Sharghi
385	51TN1474	3	9.0	8.5	9.0	9.0	8.8	2,000	Azarbaijan Sharghi
386	51TN1504	3	8.0	9.0	9.0	9.0	8.5	1,800	Azarbaijan Sharghi
387	51TN1448	3	9.0	9.0	9.0	9.0	9.0	1,700	Azarbaijan Sharghi
388	51TN1503	3	9.0	9.0	9.0	9.0	9.0	1,850	Azarbaijan Sharghi
389	51TN1455	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
390	51TN1452	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
391	51TN1488	3	9.0	9.0	9.0	9.0	9.0	2,500	Azarbaijan Sharghi
392	51TN1473	3	9.0	7.5	9.0	9.0	8.3	1,300	Azarbaijan Sharghi
393	51TN1446	3	9.0	9.0	9.0	9.0	9.0	1,730	Azarbaijan Sharghi
394	51TN1456	3	9.0	9.0	9.0	9.0	9.0	1,580	Azarbaijan Sharghi
395	51TN1493	3	8.0	9.0	9.0	8.0	8.5	2,000	Azarbaijan Sharghi
396	51TN1435	3	8.0	9.0	9.0	9.0	8.5	1,900	Azarbaijan Sharghi
397	51TN1440	3	8.0	8.5	8.0	9.0	8.3	1,900	Azarbaijan Sharghi
398	51TN1515	3	9.0	9.0	8.0	9.0	9.0	1,450	Azarbaijan Sharghi
399	51TN1485	3	9.0	9.0	7.0	9.0	9.0	1,300	Azarbaijan Sharghi
400	51TN1484	3	9.0	9.0	5.0	8.0	9.0	2,300	Azarbaijan Sharghi
401	51TN1497	3	9.0	8.5	6.0	9.0	8.8	2,000	Azarbaijan Sharghi
402	51TN1472	3	8.0	8.5	8.0	9.0	8.3	2,400	Azarbaijan Sharghi
403	51TN1447	3	9.0	9.0	8.0	9.0	9.0		Azarbaijan Sharghi
404	51TN1468	3	9.0	9.0	8.0	9.0	9.0	1,450	Azarbaijan Sharghi
404-1	51TN1468-1	2	9.0	8.0	9.0	9.0	8.5	1,450	Azarbaijan Sharghi
405	51TN1508	3	9.0	9.0	9.0	9.0	9.0	1,400	Azarbaijan Sharghi
406	51TN1428	3	8.0	9.0	9.0	9.0	8.5	2,000	Azarbaijan Sharghi
407	51TN1432	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
408	51TN1461	3	9.0	9.0	9.0	9.0	9.0	1,100	Azarbaijan Sharghi
409	51TN1502	3	9.0	9.0	9.0	9.0	9.0	1,500	Azarbaijan Sharghi
410	51TN1489	3	9.0	9.0	9.0	9.0	9.0	1,800	Azarbaijan Sharghi
411	51TN1498	3	8.0	9.0	9.0	9.0	8.5		Azarbaijan Sharghi
412	51TN1524	3	8.0	9.0	9.0	9.0	8.5		Azarbaijan Sharghi
413	51TN1153	3	9.0	9.0	9.0	9.0	9.0	2,050	Markazi
414	51TN1145	3	9.0	9.0	9.0	9.0	9.0	2,150	Markazi
415	51TN1144	3	9.0	9.0	9.0	9.0	9.0	2,100	Markazi

Continued

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
416	51TN1136	3	9.0	9.0	9.0	9.0	9.0	1,760	Markazi
417	51TN1586	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
418	51TN1578	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
419	51TN1606	3	9.0	9.0	9.0	9.0	9.0	2,100	Kordestan
420	51TN1122	3	9.0	9.0	9.0	9.0	9.0		
422	51TN1132	3	9.0	9.0	9.0	9.0	9.0		
423	51TN1129	3	9.0	9.0	9.0	9.0	9.0		
425	51TN1588	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
426	51TN1579	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
427	51TN1471	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
428	51TN1433	3	9.0	8.5	9.0	9.0	8.8	1,780	Azarbaijan Sharghi
429	51TN0510	3	7.0	9.0	8.0	9.0	8.0		
430	51TN0508	3	5.0	9.0	9.0	9.0	7.0		
431	51TN1033	2	6.0	7.5	9.0	8.0	6.8	1,050	Kordestan
432	51TN1245	3	9.0	9.0	9.0	9.0	9.0	1,320	Khorasan
433	51TN1236	3	9.0	9.0	9.0	9.0	9.0	1,580	Khorasan
434	51TN1256	3	9.0	9.0	9.0	9.0	9.0	1,180	Khorasan
435	51TN1257	3	9.0	9.0	9.0	9.0	9.0	1,420	Khorasan
436	51TN1231	3	8.0	9.0	8.0	9.0	8.5	790	Khorasan
437	51TN1239	2	5.0	7.0	8.0	9.0	6.0	1,180	Khorasan
438	51TN1217	2	7.0	6.0	7.0	8.0	6.5	1,500	Khorasan
439	51TN1215	3	9.0	9.0	8.0	9.0	9.0	900	Khorasan
440	51TN1241	3	9.0	9.0	9.0	9.0	9.0	1,360	Khorasan
441	51TN1464	3	9.0	9.0	9.0	9.0	9.0	1,320	Azarbaijan Sharghi
442	51TN1505	3	9.0	9.0	9.0	9.0	9.0	2,000	Azarbaijan Sharghi
443	51TN1445	3	9.0	9.0	9.0	9.0	9.0	2,050	Azarbaijan Sharghi
444	51TN1434	3	8.0	9.0	9.0	9.0	8.5	1,780	Azarbaijan Sharghi
445	51TN1467	3	9.0	9.0	9.0	9.0	9.0	1,450	Azarbaijan Sharghi
446	51TN1430	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
447	51TN1510	3	9.0	9.0	9.0	9.0	9.0	1,650	Azarbaijan Sharghi
448	51TN1460	3	9.0	9.0	8.0	9.0	9.0	1,350	Azarbaijan Sharghi
449	51TN1450	3	9.0	8.0	9.0	8.0	8.5	1,300	Azarbaijan Sharghi
450	51TN1466	3	9.0	9.0	9.0	9.0	9.0	800	Azarbaijan Sharghi
451	51TN1476	3	9.0	8.5	8.0	9.0	8.8	1,700	Azarbaijan Sharghi
452	51TN1501	3	8.0	8.5	9.0	9.0	8.3	2,300	Azarbaijan Sharghi
453	51TN1481	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
454	51TN1511	3	9.0	9.0	9.0	9.0	9.0	1,700	Azarbaijan Sharghi
455	51TN1500	3	9.0	9.0	9.0	9.0	9.0	1,800	Azarbaijan Sharghi
456	51TN1506	3	9.0	9.0	9.0	9.0	9.0	2,000	Azarbaijan Sharghi
457	51TN1480	3	9.0	9.0	9.0	9.0	9.0	1,900	Azarbaijan Sharghi
458	51TN1477	3	8.0	9.0	9.0	9.0	8.5	1,730	Azarbaijan Sharghi
459	51TN1471	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
460	51TN1496	3	9.0	9.0	9.0	9.0	9.0	1,000	Azarbaijan Sharghi
461	51TN1441	3	9.0	9.0	7.0	9.0	9.0	1,800	Azarbaijan Sharghi
462	51TN1429	3	9.0	9.0	8.0	9.0	9.0	1,350	Azarbaijan Sharghi
463	51TN1438	3	9.0	9.0	9.0	9.0	9.0	1,700	Azarbaijan Sharghi
464	51TN1436	3	9.0	9.0	9.0	9.0	9.0	1,830	Azarbaijan Sharghi
465	51TN1469	3	9.0	9.0	9.0	9.0	9.0	1,850	Azarbaijan Sharghi
466	51TN1462	3	9.0	9.0	9.0	9.0	9.0	630	Azarbaijan Sharghi
467	51TN1509	3	9.0	9.0	9.0	9.0	9.0	1,400	Azarbaijan Sharghi
468	51TN1499	3	8.0	9.0	9.0	9.0	8.5	2,000	Azarbaijan Sharghi
469	51TN1512	3	8.0	9.0	8.0	9.0	8.5	2,150	Azarbaijan Sharghi
470	51TN1453	3	9.0	9.0	9.0	9.0	9.0	1,650	Azarbaijan Sharghi
471	51TN1487	3	8.0	9.0	9.0	9.0	8.5	2,100	Azarbaijan Sharghi
472	51TN1458	3	9.0	9.0	8.0	9.0	9.0	1,300	Azarbaijan Sharghi
473	51TN1514	3	9.0	9.0	9.0	9.0	9.0	1,400	Azarbaijan Sharghi
474	51TN1444	3	9.0	9.0	9.0	9.0	9.0	1,800	Azarbaijan Sharghi
475	51TN1475	3	8.0	8.5	9.0	9.0	8.3	1,700	Azarbaijan Sharghi
477	51TN1869	3	9.0	9.0	9.0	9.0	9.0	482	Sistan va Baluchestan
478	51TN1491	3	8.0	9.0	8.0	9.0	8.5	1,700	Azarbaijan Sharghi
479	51TN1870	3	8.0	9.0	8.0	9.0	8.5	482	Sistan va Baluchestan
480	51TN1516	3	9.0	9.0	9.0	9.0	9.0	1,450	Azarbaijan Sharghi
481	51TN1865	3	9.0	9.0	9.0	9.0	9.0	482	Sistan va Baluchestan
482	51TN1457	3	9.0	9.0	9.0	9.0	9.0	1,300	Azarbaijan Sharghi
483	51TN1518	3	9.0	9.0	9.0	9.0	9.0	1,900	Azarbaijan Sharghi
484	51TN1867	3	9.0	9.0	9.0	9.0	9.0	482	Sistan va Baluchestan
485	51TN1866	3	9.0	9.0	9.0	9.0	9.0	482	Sistan va Baluchestan
486	51TN1513	3	9.0	9.0	9.0	9.0	9.0	1,700	Azarbaijan Sharghi
487	51TN1868	3	9.0	9.0	9.0	9.0	9.0	482	Sistan va Baluchestan

Continued

Plot No.	Accession No.	Growth habit[1]	AWS[2] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Elevation (masl)	Province
488	51TN1439	3	8.0	8.5	9.0	8.0	8.3	1,850	Azarbaijan Sharghi
489	51TN1426	2	6.0	7.0	9.0	8.0	6.5	2,100	Azarbaijan Sharghi
490	51TN1519	3	9.0	9.0	9.0	9.0	9.0		Azarbaijan Sharghi
491	51TN1507	3	9.0	9.0	9.0	9.0	9.0	750	Azarbaijan Sharghi
492	51TN1470	3	9.0	9.0	9.0	9.0	9.0	1,450	Azarbaijan Sharghi
493	51TN1150	3	8.0	8.0	9.0	9.0	8.0	2,000	Markazi
494	51TN1143	3	9.0	9.0	9.0	9.0	9.0	1,750	Markazi
495	51TN1147	3	9.0	9.0	9.0	9.0	9.0	2,050	Markazi
496	51TN1139	3	9.0	9.0	9.0	9.0	9.0	1,850	Markazi
497	51TN1151	3	9.0	9.0	9.0	9.0	9.0	2,100	Markazi
498	51TN1148	3	9.0	9.0	9.0	9.0	9.0	1,750	Markazi
499	51TN1140	3	7.0	9.0	8.0	9.0	8.0	1,920	Markazi
500	51TN1155	3	8.0	9.0	8.0	9.0	8.5	1,770	Markazi
501	51TN1142	3	8.0	9.0	9.0	9.0	8.5		Markazi
502	51TN1138	3	9.0	9.0	9.0	9.0	9.0	1,750	Markazi
503	51TN1146	3	8.0	8.0	8.0	9.0	8.0		Markazi
504	51TN1152	2	8.0	9.0	9.0	9.0	8.5	1,830	Markazi
505	51TN1581	3	9.0	9.0	9.0	9.0	9.0	1,890	Azarbaijan Sharghi
506	51TN1448	3	9.0	8.5	9.0	9.0	8.8	1,700	Azarbaijan Sharghi
507	51TN1451	2	8.0	9.0	9.0	9.0	8.5	2,130	Azarbaijan Sharghi
508	51TN1474	3	8.0	9.0	9.0	9.0	8.5	2,000	Azarbaijan Sharghi

[1]prostrate (1), semi-erect (2) and erect (3); [2]very resistant (1), resistant (3), semi-resistant (5), susceptible (7) and very susceptible (9).

Appendix 2. Traits of accessions in the Iranian alfalfa weevil-resistant collection of *Medicago sativa*.

Plot No.	Accession No.	Growth habit[1]	Plant hairiness[2]	Length of central leaflet[3]	Width of central leaflet[4]	AWS[5] 1st year	AWS 2nd year	AWS 3rd year	AWS 4th year	AWS mean	Plant height (cm)	Regrowth rate (cm/day)	Days between harvests	Fall dormancy score[6]
359	51TN0468	2	3	1	1	4.0	4.0	3.0	3.0	4.0	31.5	0.46	32	0.4
14	51TN0572	2	2	9	5	5.0	6.0	5.0	5.0	5.5	71.0	1.46	44	1.9
3	51TN0585	2	2	5	3	5.0	8.0	3.0	5.0	6.5	43.7	0.95	29	2.4
260	51TN0620	3	2	7	5	8.0	8.0	4.0	6.0	8.0	68.0	1.73	32	0.1
301	51TN0623	2	2	9	5	5.0	4.0	5.0	3.0	4.5	54.0	1.60	38	2.8
98	51TN0660	2	2	1	2	5.0	4.5	5.0	7.0	4.8	39.3	1.21	36	1.0
97	51TN0668	1	3	3	3	3.0	4.0	1.0	4.0	3.5	24.7	0.58	46	0.8
96	51TN0669	1	3	3	1	3.0	3.0	1.0	4.0	3.0	20.5	0.60	29	0.8
95	51TN0672	1	3	3	1	3.0	3.0	1.0	4.0	3.0	33.0	0.59	45	0.8
326	51TN0722	2	3	7	3	5.0	5.0	2.0	7.0	5.0	45.0	0.76	28	0.6
315	51TN1083	2	2	5	5	6.0	4.5	2.0	5.0	5.3	23.7	0.44	38	0.6
45	51TN1223	2	2	3	3	7.0	6.5	5.0	5.0	6.8	49.0	1.04	35	2.0
295	51TN1306	2	3	3	3	6.0	5.0	8.0	6.0	5.5	22.3	0.77	34	0.4
363	51TN1308	2	3	3	3	7.0	5.5	3.0	5.0	6.3	29.3	0.46	47	1.2
49	51TN1371	2	2	7	5	8.0	4.5	3.0	7.0	6.3	43.7	0.98	42	1.5
55	51TN1376	2	2	5	3	5.0	4.0	5.0	4.0	4.5	30.0	0.68	46	1.0
46	51TN1379	2	2	3	3	5.0	8.0	3.0	5.0	6.5	45.3	0.80	42	3.8
348	51TN1695	2	2	3	3	4.0	4.5	7.0	6.0	4.3	23.3	0.77	38	0.6
316	51TN1753	2	3	5	5	6.0	5.5	3.0	6.0	5.8	29.3	0.48	39	0.4
141	51TN1856	2	2	5	3	5.0	4.0	1.0	3.0	4.5	32.5	0.57	29	1.0
142	51TN1857	2	2	5	3	5.0	4.0	1.0	3.0	4.5	42.5	0.61	39	1.0

[1]prostrate (1), semi-erect (2) and erect (3); [2]nil (1), sparse (2) and dense (3); [3]1 (very short) to 9 (very long); [4]1 (very narrow) to 9 (very wide); [5]very resistant (1), resistant (3), semi-resistant (5), susceptible (7) and very susceptible (9); [6]attributing 1 score for every 5 cm of plant height.