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ORIGINAL ARTICLE

Susceptibility Evaluation of Different Cultivars of Hazelnut (*Corylus avellana* L.) to Powdery Mildew (*Phyllactinia guttata*) in Northern Iran

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A R T I C L E I N F O

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A B S T R A C T

Hazelnut (*Corylus avellana* L.) production is well-established in Iran. Cultivars that are resistant to plant diseases are needed to expand hazelnut cultivation. The present research aimed to study and compare the susceptibility of 48 Iranian, local and exotic hazelnut cultivars (*C. avellana* L.) to *Phyllactinia guttata,* the pathogen causing powdery mildew (PM). The study was conducted under naturally occurring infection at a Research station for hazelnut in the Guilan province (Astara-north of Iran), during the period 2019-2020. Experiments were arranged in a randomized complete block design with four replicates. The studied cultivars were divided in classes of susceptibility to *Ph. guttata* depending on the leaf infection (%) and disease severity index (DSI), using a 8-rating scale (0= no visible leaf symptoms to 7 = more than 85% of the leaf surface with symptoms). None of the investigated cultivars demonstrated resistance. Although no plot was scored less than 4, highly significant differences (*P*=0.01) in susceptibility among hazelnut cultivars were found. So that, 75% of the hazelnut cultivars exhibited high susceptibility to PM. No correspondence was observed within cultivars based on geographical origin. In general, Iranian superior local cultivars Gercheh, Pashmineh 89, Shast-e-Ras, Gerdoii 89 and four Spanish commercial cultivars Fertile de Coutard, Segorbe, Negret, and 'Ronde du Piedmont showed high susceptibility reaction to PM. It was recommended that while paying attention to the susceptibility of cultivars to PM, control measures should also be considered.

Introduction

Studying genetic resources can always led to exploring varieties which are tolerant to biotic and abiotic stresses (Akça *et al.*, 2020; Sarikhani *et al.*, 2021). The genus Corylus demonstrates wide morphological diversity and adaptability (Sevord *et al*., 2010). Hazelnut (*Corylus avellana* L.) is an economically important crop for its edible fruit. The total area harvested in the world for hazelnuts is about 660 000 ha. Turkey (560 000 tons) is the largest producer of hazelnut in the world followed by Italy (110 000 tons), the USA (34 000 tons), Georgia (32 000 tons), Azerbaijan (31 000 tons) and Spain (15 000 tons) (FAOSTAT, 2019).

The growth rates of area and production of hazelnut is currently being increased in Iran. Iran is the 7th largest producer of hazelnut in the world, at 21550 t, with 25500 ha of hazelnut orchards. Hazelnut production areas of Iran are present foremostly in Guilan (north of Iran, 16000 ha), followed by Qazvin (northwest of Iran, 3300 ha), Mazandaran (north of

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Iran, 1400 ha), Zanjan (northwest of Iran, 400 ha), Ardebil (northeast of Iran, 315 ha), Golestan (north of Iran, 300 ha) and Qom (north-central Iran, 170 ha) provinces. Guilan is the top region of hazelnut production in Iran because of the ideal climate, 70% of hazelnut is harvested in the Eshkevarat area (Guilan province). There is considerable interest in expanding the cultivation of hazelnut to other regions in Iran. The most important advantage of Iranian hazelnut is that pesticides are not used in orchards. Also, chemical fertilizers are applied sparingly, and mainly organic fertilizers and animal manures are used. The market for hazelnuts has increased greatly in the past few years in the world and Iran is struggling to make its name (Financialtribune. com/articles/economy-domestic economy/75837/hazelnut production-at; Anonymus, 2018). In recent years, environmental conditions affect the growth, development, or productivity of hazelnuts in the world. Some of the diseases and pests were identified along with increasing the area under cultivation of hazelnut and climate change in Iran. At present, Powdery mildew (PM) is one of the most common diseases in almost whole hazelnut producing areas of Iran. Recently, PM has become more important with increased application of nitrogen fertilizer, water scarcity, and depletion of water availability in soil (Helmstetter *et al*., 2020). So, these adverse conditions may cause significant declines in crop yield and resistant to pests/ and or diseases. PM usually has no damaging damage to hazelnut production except when the infection is heavy due to biotic and abiotic stresses. PM disease is one of the most common fungal diseases of hazelnut in all production regions of Iran, Azerbaijan, Turkey, and Georgia (Meparishvili *et al*., 2019; Abasova *et al*., 2018; Arzanlou *et al*. 2018; Sezer *et al*., 2017). PM is a fungal disease that is identified by white powdery layers that can form on the upper and lower surface of leaves and fruits of hazelnut (Fig. 1). When PM infects the majority of the foliage, the plant weakens and the leaves defoliate. The PM disease is caused by two different species, *Phyllactinia guttata* (Wallr. et Lev.) Fr. and *Erysiphe corylacearum* Braun U and Takam S (Bradshaw *et al*., 2021; EPPO 2021; Mezzalama *et al*. 2020; Rosati *et al*., 2020; Heluta *et al*. 2019; Khodaparast *et al*., 2019; Abasova *et al*. 2018; Arzanlou *et al*., 2018; Braun and Cook, 2012; Beenken *et al*., 2010; Pirnia *et al*., 2007; Davari *et al*., 2002; Bremer, 1948). *P. guttata* was most common cause of PM on hazelnut in Iran, Romania and the USA (Pirnia *et al*., 2007; Hartney *et al.* 2005; Davari *et al*., 2002; Razaz-Hashemi and Zakeri, 2000; Taherzadeh *et al*., 1998). Recently, *E. corylacearum* on *C. avellana* was reported also in Romania (Chinan and Mânzu, 2021), Austria (Voglmayr *et al*., 2020), Italy (Mezzalama *et al*., 2020), Switzerland (Beenken *et al*., 2020), Ukraine (Heluta *et al*. 2019) and Iran (Khodaparast *et al*., 2019; Arzanlou *et al*., 2018),

Fig. 1. Symptoms of hazelnut powdery mildew infection. White powdery spots on upper leaf surface (left) and infected fruits ripen prematurely

One of the most important priorities of sustainable horticulture in the country is to achieve the planting pattern of horticultural crops based on climatic conditions and the selection of cultivars that are compatible with the conditions of each region, especially cultivars resistant to pests and diseases has doubled this need. Cultivar resistance (or tolerance) is a necessary part of disease management in many agricultural systems. Although PM has been reported for many years from the hazelnut growing regions of Iran, in recent years it has developed greatly in native and improved hazelnut cultivars.

There are different types and cultivars of hazelnuts across the world that may have some degree of susceptibility to powdery mildew. There is no current data as to which hazelnut cultivars (*C. avellana* L.) are PM susceptibility (or resistant) and which ones are not. Less susceptibility to PM disease is one of the aims of hazelnut breeders because in this case there is no need to use fungicides or by using fungicides in necessary cases, the disease can be completely controlled.

Material and Methods

Experimental site location

During 2019-20, experiments were conducted in field conditions at Horticultural Research Station, Abbas-Abad, Astara (north of Iran) as one of the national hazelnut germplasm collections which 50 introduced and 22 Iranian (or local) cultivars/ and or genotypes grown and preserved. The ecological conditions for hazelnut are the most suitable for this species to grow and PM disease occurrence (Table 1).

Table1. Climatic parameters for Astara Horticultural Research Station

Altitude (m)	Min. Temp.(°C)	Max. Temp.(°C)	Humidity of the first 5 months of the year (%)	Average Precipitation in the first 5 months of the year(mm)	Annnnual rainfall (mm)
22	-5	36.5	79	281	1348

Selection of hazelnut cultivars

The 48 Iranian, local, and foreign hazelnut cultivars (*Corylus avellana* L.) were assessed in this study (Table 2). The experiments were done in a completely randomized block design with four replicates. No pesticide was used in the experimental site.

Sampling method

The samples were obtained after ensuring the relative spread of PM infection in the orchard. Twenty leaves were randomly collected from each direction the north, south, east, west, and the center of the trees.

Determination of incidence and severity of powdery mildew disease

Evaluations were based on the natural PM infection of hazelnut leaves in the experimental site. Disease occurrence was evaluated by calculating the percentage of infected leaves and recorded for every cultivar. The susceptibility response of hazelnut cultivars was determined as disease severity index (DSI) according to the type of leaf infection. To do this, first, the margins of the layers of mildew and leaves were drawn on transparent plastic talc and transferred to the white paper. Then, the area on the surface of the leaves was measured using a digital planimeter. Disease ratings followed the eight-point rating index based on the infection area (covered with mildew): (0=no visible infection; 1= > 0-5% of leaf area affected; 2= > 5-15%; 3=> 15-30%; > 4=30-45%; > 5=45-65%; > 6=65-85%; 7=> 85-100%) (Wang *et al*., 1995). The DSI was calculated from the following equation:

$$(\%)\ DSI = [\Sigma\ (\text{severity class} \times \text{number of leaves per class}) / (\text{highest severity class} \times \text{Total number of leaves})] \times 100$$

The susceptibility level of hazelnut cultivars to PM was obtained based on the DSI (Wang *et al*., 1995; Table 3).

Table 2. Five Levels of reactins to powdery mildew

Disease severity Index (%)	Resistance level
0	Immune
> 0-5	High resistance
> 5-25	Resistance
> 25-50	Susceptible
> 50-100	High susceptible

Table 3. The hazelnut cultivars in this study

NO.	Cultivar/ Genotypes	Area of origin	NO.	Cultivar/ Genotypes	Area of origin	NO	Cultivar/ Genotypes	Area of origin
1	Ganja	Azebaijan	**17**	Zorchneskiy	Georgia	**33**	Dedobestani	Georgia
2	Kazmaz	Georgia	**18**	Negret	Spain	**34**	President	Turkey
3	Eizdeb	Georgia	**19**	Nemsa	Georgia	**35**	Khachakhkuria	Georgia
4	Qafqaz	Azerbaijan	**20**	Dokominskiy	Georgia	**36**	Fertile de Coutard	Spain
5	Souchi	Russia	**21**	Yagli findiq	Azerbaijan	**37**	'Ronde du Piedmont'	Spain
6	Paeuner	Georgia	**22**	Boliba	Georgia	**38**	Kristina	England
7	Shveliskhura.	Georgia	**23**	Vartashen	Azerbaijan	**39**	Trabzon	Turkey
8	Gerdoii 89	Iran	**24**	Futburami	Georgia	**40**	Zaqatal	Azerbaijan
9	Gercheh	Iran	**25**	Baigane	Azerbaijan	**41**	Khastenskiy	Georgia
10	Chelsea-Dzudzu	Georgia	**26**	Atrak	Azerbaijan	**42**	Rimskiy	Georgia
11	Morfilessky	Georgia	**27**	Koloisiva	Georgia	**43**	Reysinat	Georgia
12	Bağmarnsky	Georgia	**28**	Shast-e-Ras	Iran	**44**	Pronnes	Georgia
13	Victoria	England-Australia	**29**	Merveille de Bollweiler	Germany	**45**	Quban	Azerbaijan
14	Khechitoy	Georgia	**30**	Daviana	England	**46**	Long de spain	Spain
15	Perestroika	Russia	**31**	Segorbe	Portugal	**47**	'Foşa'	Turkey
16	Qalib	Azerbaijan	**32**	Pashmineh 89	Iran	**48**	Deroche	Georgia

Statistical analysis

All data were statistically analyzed using the software SAS 6.1 Data on the infected leaf% and severity index were log- and ArcSin√x transformed, respectively. Significant differences among leaf disease and severity index were calculated after Duncans Multiple Rang test at *P<0.01*.

Results

The results from the analysis of variance for 2019 and 2020 data revealed statistically significant differences among cultivars in terms of occurrence (leaf infection %) and DSI % of PM of hazelnut (*Corylus avellana* L.) cultivars (*P*=0.01) (Table 4). Also, compound analysis of variance for occurance and DSI % revealed that there were significant differences among cultivars not statistically significant differences between years of experiments (Table 6). This study showed low variation of PM occurrence (leaf infection %) and DSI % on individual hazelnut cultivars grown closely to each other (Table 5). The hazelnut cultivars were in the ranges of susceptible to high susceptible (Table 5). As has been shown in Table 5, about 83.3% (39 cultivars) and 52% (25 cultivars) of hazelnut cultivars were the highest susceptible in 2019 and 2020, respectively. Other cultivars were susceptible to PM. Cultivars Dedobestani (98.13%, 85.24%), Pronnes (83.15%), Baigane (31.23%) and Boliba (36.90%) showed the highest and lowest DSI, respectively (Table 5).

Iranian cultivars "Pashmineh 89" and "Gerdoii 89" (local cultivar) were high susceptible. Also, Iranian cultivars Shast-Ras and "Gercheh" were identified as high susceptible and susceptible, respectively (Table 5) (Fig. 2). In addition, spanish cultivars" Fertile de Coutard" and Segorbe, newly introduced commercial cultivars in the Iranian hazelnut cultivation expanding program, were identified as a high susceptible cultivars (Table 5). Susceptible cultivars showed very leaves with visible mildew layer (s). Cultivars Pashminneh 89 (98.50%), Dedobestani (92.50%), Pronnes (91%), Long de spine (90%) and Baigane (51%), Boliba (52%), Atrak (52%), Nemsa (52%) showed the highest and lowest incidence, respectively (Table 5). There were variable infection rates with PM among different hazelnut cultivars with leaf infection% ranging between 51.50 and 91% and DSI between 37.68 and 86.81% (Table 6). The two-year compound analysis of variance indicated that the effects of year, cultivar and Year×cultivar on leaf infection% and DSI% were significantly different (*P*=0.01) (Table 6). Based on the combined mean comparison of leaf infection traits (% leaf infection and SI) cultivars "Dedobestani" (86.81%) and President (84.46%) had the highest and Boliba (41.83%) had the least DSI%, respectively (Table 7). Also, the highest and the least leaf infections (%) were observed in "Dedobestani "(91%) and "Boliba" (51.50%), respectively (Table 7). Based on the Table 7, only 12 hazelnut cultivars include the 7 Georgian (Eizdeb, Paeuner, Futburami, Bağmarnsky, Morfilessky, Koloisiva and Boliba) and 4 Azerbaijan cultivars (Qafqaz, Yagli findiq, Baigane and Atrak) and cultivar Victoria were grouped as the susceptible cultivars. The cultivars 'Fertile de Coutard', 'Segorbe', 'Ronde du Piedmont' and Negret were high susceptible to PM (Fig. 2). Also, Iranian cultivars and genotypes Shast-Ras, Gercheh, Pashmineh 89 and Gerdoii were identified as high susceptible to PM (Fig. 2).

Table 4. Analysis of variance of occurance (leaf infection %) and severity index (DSI %) of powdery mildew for hazelnut (*Corylus avellana* L.) cultivars (years 2019 and 2020)

		MS	**MS**		
		2019	**2020**		
S.O	**d.f**	**D.S.I (%)**	**Leaf infection%**	**D.S.I (%)**	**Leaf infection%**
Cultivar	47	86.722*	17355.781*	11530.724*	563.844*
Error	144	62.042	44.128	64.258	86.722

**: significant at 0.01

Discussion

Since chemical control methods are known to be harmful to human health and the environment, therefore, the identification and use of resistant cultivars of hazelnut (*C. avellana*) as a sustainable way is one of the most economical and safest methods of disease management is necessary (Monir and Manadal, 2016).

This study was the first that evaluate the infection of PM in different cultivars of hazelnut in Iran and the world. In recent years, powdery mildew is one of the limiting factors for hazelnut production, especially in rainfed orchards of Iran. The disease is now recognized to be widespread across the sea region and 70%–100% of trees are affected in areas close to sea level (Houshyarfard, Unpublished). Hazelnut orchards in many villages of Eshkevarat, Roudsar (Gilan province), Amlash and Siahkal (Eastern Guilan province), and Alamut region (Qazvin province, north-western Iran) suffer from various unfavorable status including fog, non- standard planting distance, poor pruning, nutritional problems, and water shortage. Information on the susceptibility to PM on hazelnut cultivars is based on field observation and grower experience rather than systematic studies. We have demonstrated that under natural conditions, two growing seasons provided sufficient time to observe hazelnut phenotypes while minimizing escapes. This study showed that the effects of environmental conditions during two growing seasons (2019-2020) were significant on the occurance% and DSI% of PM. In this study, PM has spread rapidly in the hazelnut orchard of Astara Research Station. Our findings revealed the occurrence and severity of PM disease depended greatly on cultivar susceptibility and environmental conditions. The difference in susceptibility of hazelnut cultivars under natural infection of the orchard is due to the effect of suitable weather conditions such as temperature and relative humidity. So, leaf samples were collected during mid-summer 2019-2020 before defoliation was occurred due to severe leaf infection. Because the grading of leaf infection at the end of the growing season is difficult to distinguish. A disease severity estimate is considered to give an accurate indication PM effect on the hazelnut or of the efficacy of control measures. The issue of leaf susceptibility is one of the most important indicators for evaluating of the susceptibility of hazelnut cultivars to PM (Wang *et al*., 2007). Commercial hazelnut cultivars with susceptiblity to PM were observed with high DSI% of PM. The 75% of the hazelnut cultivars exhibited high susceptibility to PM. So, the primary selection of hazelnut cultivars for PM could be based on leaf susceptibility. The level of susceptibility of hazelnut cultivars to PM was widely variable. It seemed that internal variations among hazelnut cultivars were normal due to their genetic heterogenicity of them. According to Lucas *et al*. (2018) several hazelnut germplasms studied had a high level of resistance to PM and could be used in hazelnut breeding programs as a resistant parent to transfer resistance gene (s).

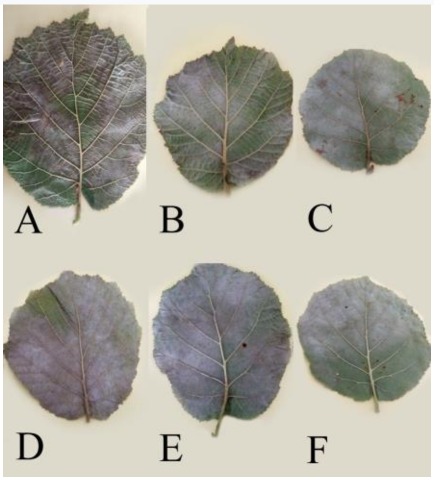

Fig. 2. Powdery mildew susceptibility of hazelnut cultivars
(A: Segorbe; B: Shast-Ras; C: Ronde du Piedmont; D: Negret; E: Fertile de Coutard; F: Gerdoii)

Conclusions

In some countries, PM is of little importance, but in most countries, including Iran, on some hazelnut cultivars (especially local populations of hazelnut) is one of the main and important problems. PM disease outbreak has drastically influenced yields across Iran and climate change is emerging as a new threat to hazelnut cultivation. The amount of PM yield loss varies depending on weather conditions, cultivar susceptibility and field management. So far, no study has been conducted on susceptibility of Iranian and foreign (exotic) cultivars to PM. Iranian hazelnut cultivars Gerdoii 89, Shast-e-Rass, Pashmineh 89, Gercheh, and foreign commercial cultivar "Fertile de Coutard" with good quantitative and qualitative properties, were highly susceptible to PM. Because of tested hazelnut trees have similar age/size and canopy density the variability of PM was reduced among trees. We concluded that there are no hazelnut cultivars that are potentially valuable sources of PM resistance. All the commercially and native hazelnut cultivars in Iran are susceptible to PM. In recent years, PM disease has been recognized as one of the hazelnut diseases in many orchards of Guilan province. It was concluded that the variation was not related to the geographic distribution of the cultivars. During the growing season, the PM pathogen produces abundant asexual spores (conidia) that are dispersed by the wind and do not need free moisture to germinate. Infection usually occurs at relative humidity above 70%, which is often available at the underside of leaves, and on days when humidity is low, leaf infection usually occurs at night or in the early morning hours when relative humidity is high. It was found that PM is a restriction factor of production on all hazelnut cultivars if not controlled. It is recommended that in the establishment of new hazelnut orchards while considering the compatibility of the cultivar with the climatic conditions of the region if the conditions for the development of PM were favorable, the planting of highly susceptible cultivars should be avoided. Also, to reduce the disease severity, proper pruning that ensures proper air circulation in the tree canopy and a balanced amount of nitrogen fertilizer should be done. Application of fungicides that are low in dose, low risk, and environmentally friendly should be used as soon as signs of PM infection were observed. However, the pathogen resistance to fungicides should be considered and fungicides with a different mode of action should be used.

Table 5. Effect of hazelnut cultivars on powdery mildew occurrence (leaf infection %) and disease severity index (DSI) at Astara Research station during two years (2019-2020).

Cultivar NO.	**Leaf infection%**		**DSI (%)**			
	2019	**2020**	**2019**	**RL[x]**	**2020**	**RL[x]**
32	98.50a	76.50cde	78.69bcdefg	**HS**	61.35cdefgh	**HS**
43	94.00ab	58.50ijklmno	54.43jklmnopqr	**HS**	58.50 o	**HS**
45	92.00abc	66.50 efghijkl	75.81defghijkl	**HS**	57.65defghijk	**HS**
33	89.50abcd	92.50a	98.13a	**HS**	85.24a	**HS**
8	83.50bcde	79.75bc	84.09abcde	**HS**	61.32 cdefgh	**HS**
35	82.50bcdef	79.75bc	50.20 lmnopqr	**HS**	44.85jklmnop	**S**
10	82.50bcdef	78.50bcd	82.01abcdef	**HS**	65.87cdef	**HS**
1	82.00bcdef	71.00cdefgh	81.59abcdef	**HS**	67.90bcde	**HS**
37	78.00cefg	68.50defghi	66.61 e-o	**HS**	57.97defghij	**HS**
31	76.00defgh	73.50cdef	75.19bcdefghi	**HS**	62.77cdefg	**HS**
46	74.00efghi	90a	92.26abc	**HS**	73.65 abc	**HS**
38	74.00efghi	76.50cde	77.43bcdefgh	**HS**	68.90bcd	**HS**
40	73.50efghij	61.50ghijklmno	60.52f-p	**HS**	52.47 fghijklm	**HS**
20	72.50efghijk	70.50cdefgh	71.87defghijk	**HS**	53.02fghijklm	**HS**
44	71.50efghijkl	91.a	94.28ab	**HS**	83.15 a	**HS**
2	71.50efghijkl	67.00efghijk	62.74fghijklmno	**HS**	54.15 fghijkl	**HS**
36	70.00efghijklm	80.00bc	81.40abcdef	**HS**	59.92defghi	**HS**
7	69.5 efghijklm	67.50defghij	59.54fghijklmnop	**HS**	50.53 ghijklmn	**HS**
5	68.50 e-m	66.75efghijkl	68.01efghijklmn	**HS**	54.35 fghijkl	**HS**
29	67.00fghijklmn	64.50fghijklmn	69.65efghijklm	**HS**	54.65 efghijk	**HS**
16	67.00fghijklmn	65.50efghijklm	63.95efghijklmno	**HS**	47.82hijklmnop	**S**

3	64.00ghijklmn	60.50hijklmno	64.39 e-o	**HS**	48.20 hijklmnop	**S**
39	63.00g-m	71.00cdefgh	74.01 cdefghij	**HS**	54.05 fghijklm	**HS**
14	63.00ghijklmn	61.00ghijklmno	64.53efghijklmno	**HS**	47.00ijklmnop	**S**
47	62.50 ghijklmn	72.25cdefg	74.02cdefghi	**HS**	54.53 efghijkl	**HS**
34	62 ghijklmn	88ab	89.84abcd	**HS**	78.97ab	**HS**
18	61.50hijklmn	60hijklmno	63.62fghijklmno	**HS**	49.05ghijklmnop	**S**
6	60.50hijklmn	64.25fghijklmn	40.35pqr	**S**	46.68ijklmnop	**S**
17	60.00 hijklmn	59ijklmno	57.64hijklmnopq	**HS**	51.17ghijklmn	**HS**
48	59.5 ijklmn	61.00ghijklmno	66.60efghijklmno	**HS**	50.17ghijklmno	**HS**
42	59.5 ijklmn	54.50mno	53.69jklmnopqr	**HS**	48.11ghijklmnop	**S**
28	59.5 ijklmn	56.00jklmno	53.26klmnopqr	**HS**	43.95jklmnopq	**S**
30	59.00 I-N	56.50jklmno	50.33lmnopqr	**HS**	46.37ijklmnop	**S**
15	58.00 ijklmn	55.50klmno	54.89ijklmnopqr	**HS**	44.67jklmnop	**S**
21	57.50 jklmn	54.50mno	52.62klmnopqr	**HS**	44.83ghijklmnop	**S**
4	57.50 jklmn	58.25ijklmno	48.53nopqr	**S**	35.22pq	**S**
9	57.00 klmn	54.50lmno	37.52qr	**S**	44.38jklmnopq	**S**
27	56.50 klmn	54.00mno	40.92pqr	**S**	40.43lmnopq	**S**
24	56.50 klmn	54.50mno	47.21opqr	**S**	44.05jklmnopq	**S**
41	56.00 klmn	71.25cdefgh	72.25defghijk	**HS**	56.67defghijk	**HS**
26	55.50 klmn	52.00 o	38.27qr	**S**	40.02mnopq	**S**
23	55.50 klmn	53.00no	49.82mnopqr	**S**	46.97ijklmnop	**S**
12	55.00 klmn	54.00mno	52.51klmnopqr	**HS**	37.38nopq	**S**
13	55.00mn	53.00no	52.20klmnopqr	**HS**	37.25nopq	**S**
11	55.00 mn	50.00mno	51.74klmnopqr	**HS**	43.52klmnopq	**S**
25	54.50mn	51.00 o	36.84r	**S**	31.23q	**S**
19	54.50mn	52.00 o	51.75klmnopqr	**HS**	45.32jklmnop	**S**
22	52.00n	51.00 o	36.90r	**S**	36.32opq	**S**

Cultivars followed by the same letter are not significantly different at .01 level by Duncan's multiple range test

X=Susceptibility level: HS= Highly susceptible; S= Susceptible

Table 6. Compound analysis of variance for occurance (leaf infection %) and disease severity index (DSI %) of powdery mildew of hazelnut (*Corylus avellana* L.) cultivars.

		MS	
S.O	**d.f**	**Leaf infection%**	**D.S.I (%)**
Year	1	356.510**	10019.740**
Cultivar	47	1666110.511**	1268180.722**
Year×Cultivar	47	218.633	31.256
Error	288	65.425	63.150
Total error	384		

**: significant at 0.01

Table 7. Compound mean comparisons of occurance (leaf infection %) and disease severity index (DSI %) of powdery mildew for hazelnut (*Corylus avellana* L.) cultivars

Cultivar NO.	Leaf infection%	DSI (%)	RL[x]	Cultivar NO.	Leaf infection%	DSI (%)	RL[x]
33	91.00a	86.81a	HS	**48**	60.25ijklmno	56.83hijklm	HS
44	81.50bc	84.46a	HS	**14**	62.00ghijklmn	50.22lmnopq	HS
46	82.00bc	78.19b	HS	**3**	62.25ghijklmn	49.06mnopq	S
34	75.00cdef	82.03ab	HS	**35**	71.25defg	51.02klmnop	HS
36	75.00cdef	65.16defgh	HS	**18**	60.75hijklmno	55.84hijklm	HS
8	81.63bc	68.53cde	HS	**17**	59.50ijklmno	57.36ghijklm	HS
10	80.50bcd	69.68cd	HS	**43**	76.25cdef	55.22ijklmn	HS
38	75.25cdef	74.66bc	HS	**4**	57.87jklmno	37.68 r	S
32	87.50ab	67.21cdef	HS	**30**	58.00jklmno	51.73jklmno	HS
31	74.75cdef	66.37cdefg	HS	**28**	58.00jklmno	50.09lmnopq	HS
47	67.39efghij	61.09defghij	HS	**15**	57.00klmno	51.18klmnop	HS
41	63.64ghijklm	62.78defghi	HS	**9**	56.25lmno	48.82mnopq	HS
39	67.00efghij	60.33efghijk	HS	**42**	57.00klmno	54.90ijklmn	HS
1	76.50cde	769.17cde	HS	**24**	55.50mno	49.19mnopq	S
20	71.50defg	58.98fghijk	HS	**21**	56.00mno	49.85lmnopq	S
37	73.25cdef	62.77defghi	HS	**27**	55.25mno	45.93nopqr	S
7	68.50efghi	57.76ghijklm	HS	**12**	54.75mno	44.97opqr	S
2	69.25efgh	55.39ijklmn	HS	**11**	54.50mno	48.15mnopq	S
5	67.63efghij	55.38ijklmn	HS	**23**	54.25mno	51.16klmnop	HS
45	79.25bcd	63.69defghi	HS	**13**	54.00mno	43.69opqr	S
16	66.25fghijk	56.14hijklm	HS	**26**	53.75mno	46.06nopqr	S
29	65.75fghijk	59.89efghijk	HS	**19**	53.25no	51.32klmnop	HS
6	63.38ghijklmn	49.14mnopq	S	**25**	52.75no	41.35qr	S
40	67.50efghij	57.35hijklm	HS	**22**	51.50 o	41.83pqr	S

X=Susceptibility level: HS= Highly Susceptible; S= Susceptible

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