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POWDERY MILDEW DISEASE IN SOME NATURAL AND EXOTIC PLANTS OF ISTANBUL, TURKEY

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Abstract

Powdery mildew is a disease that affects a wide range of plants and is caused by many different species of fungi. The disease is easy to diagnose since its symptoms are quite distinctive. Powdery mildew usually produces a white powdery substance that grows on both sides of the leaf surfaces. These leaves may become twisted, distorted, then wilt and die as a result of infection. Although humidity requirements for germination vary, all powdery mildew species can germinate and get infected in the absence of water. The powdery mildews seldom kill their hosts; the fungi reduce the amount of photosynthesis taking place, increase respiration and transpiration, and cause slower growth. This study was carried out between the years 2008 and 2010, and diseased plant samples were collected from urban lands, especially in parks, public and private gardens, road edges, medians and nurseries in 36 of 39 districts of Istanbul. In this study, 43 powdery mildew fungi species were observed and identified on 73 different plant species. Some of these fungi observed on a single plant species were *Erysiphe convolvuli* var. *convolvuli, E. flexuosa, E. lagerstroemiae, E. platani, E. sparsa, E. syringae, E. trina, E. viburni, Leveillula taurica, Microsphaera alni* var. *vaccinii, M. alphitoides, M. berberidicola, M. diffusa, M. grossulariae, M. platani, M. quercina, Oidium* sp., *O. begonia, O. euonymi-japonica, O. lauraceum, O. lini, Peronospora erodii, Phillactinia guttata, Sphaerotheca fusca, S. humuli, S. lanestris, S. macularis, S. pannosa* var. *rosae, Uncinila aceris, U. circinata, U. clintonii, U. geniculata, U. necator, U. Parvula* and *U. salicis*. Some powdery mildew fungi were cosmopolitan and showed parasitic features for many different plant species. These fungi are *Microsphaera alni* (11 plant species), *Erysiphe polygoni* (9 plant species), *Erysiphe cichoracearum* and *Phyllactinia corylea* (8 plant species).

Introduction

The powdery mildew fungi cause significant diseases on a range of crops, and different species of fungi are involved depending on the plant affected (Jahn *et al*., 2002; Lebeda *et al*., 2008; Kristkova *et al*., 2009). They are important plant pathogens, which are obligately parasitic on the surface of leaves, stems, fruits, and flowers of a wide range of angiosperms (Takamatsu *et al*., 1998). The fungi usually do not require moist conditions and their asexual spores can germinate and infect in the absence of water, moreover moisture reduces the viability of their conidia. Therefore, they are more prevalent than many other diseases under dry summer conditions in great number of countries (Flint, 1998; Carlile *et al*., 2001).

All powdery mildew fungi require living plant tissue to grow. The disease can usually be recognized in most crops by the light-colored, powdery spore growth that forms on shoots, both sides of leaves, and sometimes flowers. On vegetable crops, powdery mildew usually appears first as yellow spots on the upper leaf surface of older leaves; these spots develop the characteristic powdery growth and symptoms speared to the undersides of leaves and stems (Flint, 1998). Severe powdery mildew reduces seed quality and may discolor seeds and impairs flavor of the harvested product (Koike *et al*., 2007).

On perennial host plants such as grapes, raspberries and some fruit trees, powdery mildew can survive from one season to the next in infected buds or as fruiting bodies on the bark of stems and trunks. Special spores are produced that allow over winter survival of the species that cause the disease in lettuce and peas and certain other crops (Flint, 1998) (Table 1).

Table 1. Host plants and powdery mildew fungi caused disease.

Host plants	Powdery mildew fungi
Acer negundo	*Uncinula aceris - Uncinula circinata*
Acer platanoides	*Phyllactinia corylea*
Acer pseudoplatanus	*Erysiphe platani*
Aesculus hippocastanum	*Erysiphe flexuosa*
Alnus glutinosa	*Erysiphe polygoni*
Anthemis sp.	*Erysiphe sparsa*
Antırrhınum sp.	*Oidium* sp.
Begonia sp.	*Oidium begoniae - Erysiphe cichoracearum*
Berberis crataegina	*Microsphaera berberidis*
Berberis julianae	*Phyllactinia guttata*
Berberis thunbergii	*Microsphaera berberidicola*
Betula pendula	*Microsphaera alni - Phyllactinia corylea*
Calendula sp.	*Erysiphe cichoracearum - Erysiphe polygoni*
Campanula sp.	*Erysiphe cichoracearum*
Catalpa bignonioides	*Phyllactinia corylea - Microspahaera alni* var. *vaccinii*

Table 1. (Cont'd.).

Host plants	Powdery mildew fungi
Celtis australis	*Uncinula parvula*
Chrysanthemum sp.	*Erysiphe cichoracearum*
Clematis sp.	*Erysiphe polygoni*
Convolvulus arvensis	*Erysiphe convolvuli* var. *convolvuli*
Cornus sp.	*Microsphaera alni - Phyllactinia corylea*
Corylus avellana	*Phyllactinia corylea - Microsphaera alni*
Crataegus monogyna	*Podosphaera oxyacanthae - Phyllactinia corylea*
Cydonia sp.	*Podosphaera leucotricha*
Dahlia sp.	*Erysiphe polygoni - Erysiphe cichoracearum*
Dianthus sp.	*Oidium* sp.
Erodium malacoides	*Peronospora erodii*
Euonymus japonicus	*Microsphaera alni*
Euonymus sp.	*Oidium euonymi-japonici*
Geranium molle	*Sphaerotheca humuli*
Gleditsia triacanthos	*Microsphaera alni*
Helianthus annuus	*Erysiphe cichoracearum*
Hordeum murinum	*Blumeria graminis*
Hydrangea sp.	*Erysiphe polygoni*
Inula sp.	*Erysiphe cichoracearum*
Lagerstroemia indica	*Erysiphe lagerstroemiae*
Laurus nobilis	*Oidium lauraceum*
Linum usitatissimum	*Oidium lini*
Liriodendron tulipifera	*Erysiphe polygoni - Phyllactinia corylea*
Lonicera sp.	*Erysiphe polygoni - Microsphaera alni*
Lycopersicon esculentum	*Leveillula taurica - Oidium lycopersicum*
Mahonia aquifolium	*Microsphaera berberidis*
Malus sp.	*Podosphaera leucotricha*
Morus alba	*Uncinula geniculata*
Paulownia sp.	*Phyllosticta paulowniae*
Plantago lanceolata	*Podosphaera plantagini*
Plantago major	*Podosphaera plantagini*
Plantago minor	*Podosphaera plantagini*
Platanus occidentalis	*Microsphaera alni*
Platanus orientalis	*Erysiphe platani*
Polygonum aviculare	*Erysiphe polygoni*
Quercus cerris	*Microsphaera alphitoides*
Quercus frainetto	*Microsphaera alphitoides - Microsphaera quercina*
Quercus hartwissiana	*Erysiphe trina*
Quercus infectoria	*Phyllactinia corylea*
Quercus petraea	*Sphaerotheca lanestris*
Quercus sp.	*Microsphaera alni*
Ranunculus costantinopolitanus	*Sphaerotheca humuli - Erysiphe polygoni*
Robinia pseudoacacia	*Microsphaera diffusa*
Rosa sp.	*Sphaerotheca pannosa* var. *rosae*
Salix babylonica	*Uncinula salicis*
Sambucus ebulus	*Sphaerotheca humuli*
Sambucus nigra	*Microsphaera grossulariae*
Spiraea sp.	*Microsphaera alni*
Spiraea vanhouttei	*Podosphaera oxyacanthae*
Syringa vulgaris	*Erysiphe syringae*
Syringa vulgaris	*Microsphaera alni*
Taraxacum officinale	*Sphaerotheca fusca*
Tilia platyphyllos	*Microsphaera alni - Uncinila clintonii*
Veronica sp.	*Sphaerotheca humuli*
Viburnum tinus	*Erysiphe viburni*
Viola sp.	*Sphaerotheca macularis*
Vitis vinifera	*Uncinula necator*
Wisteria sinensis	*Erysiphe cichoracearum*

Most powdery mildew fungi grow as thin layers of mycelium on the surface of the affected plant part (Flint, 1998). Spores of these fungi, which are carried by wind to new hosts germinate on the leaf surface and establish haustoria in the epidermal cells (Carlile *et al*., 2001). While most of them are entirely superficial except for haustoria, which penetrate epidermal cells, the three genera; *Leveillula, Phyllactinia,* and *Pleochaeta,* form endophytic mycelia and put haustoria into mesophyll cells (Takamatsu *et al*., 1998). Powdery mildew species can germinate and infect the host plant in absence of water although humidity requirements vary for germination. In most cases, spores are killed and germination and mycelial growth are inhibited by free moisture. Moderate temperatures and shady conditions are generally favorable for powdery mildew development (Flint, 1998). Disease severity is usually higher in late summer seasons (Koike *et al*., 2007).

Disease control is generally achieved by the use of fungicides, including sulfur and sterol biosynthesis inhibitors (Zahavi *et al*., 2001). Elemental sulphur was one of the first fungicides to be introduced, and is still used to prevent commercially important powdery mildew infections (Carlile *et al*., 2001). However, fungicide-resistant strains of the pathogen have developed both in Europe and the US (Ypema *et al*., 1997; Zahavi *et al*., 2001). Additionally, the use of protective chemicals raises concerns about the environment and human health. Therefore, the importance of biological methods for plant protection has increased today (Rankovic, 1997). In most cases, planting resistant varieties or avoiding the most susceptible varieties and following good cultural practices will adequately control powdery mildew (Flint, 1998). One of the ways to overcome the disease is the use of hyperparasites fungi (Rankovic, 1997). Fungi of the genus *Ampelomyces* are well known hyperparasites and are widely distributed on the powdery mildews (Sztejnberg *et al*., 1989; Rankovic, 1997). Furthermore, the yeast *Tilletiopsis minor* is also known as a hyperparasites of powdery mildews as well (Carlile *et al*., 2001). Lately, plant disease resistance genes were isolated and transferred into some plants and resistant varieties obtained by tissue culture and gene transfer techniques to handle this disease (Li *et al*., 2003; Zhao *et al*., 2006; Akkurt *et al*., 2007; Wan *et al*., 2007; Perugini *et al*., 2008; Luo *et al*., 2009).

In this study, in total, 36 of 39 districts of Istanbul (Excluding Çatalca, Silivri and Şile) were visited in both Asian and European sides and diseased plant samples were collected during the growing periods of 2008-2010. Many different fungi species, which caused powdery mildew disease on the leaves of natural and exotic plants were identified and reported along with their hosts.

Materials and Methods

Study area: Istanbul, which is located in the north-west part of Turkey (41° 01.2' N, 28° 58.2' E), is one of the most populous cities of Eurasia and Turkey's cultural and financial centre. It extends both on European (Thrace) and Asian (Anatolia) sides of the Bosphorus, therefore the only metropolis in the world, which is situated on two continents (Fig. 1) (Kaya & Curran, 2006; Altay *et al*., 2010a; Osma *et al*., 2010; Yasar *et al*., 2010; Municipality, 2011). Istanbul has approximately 5,100 km^2 land area and has the highest population (12,573,836), and continuing to increase the fastest in Turkey (Tuikapp, 2010; Municipality, 2011). In addition to its rich history, high population and productive economy, Istanbul also has wide variety of ecological features (Altay *et al*., 2010a).

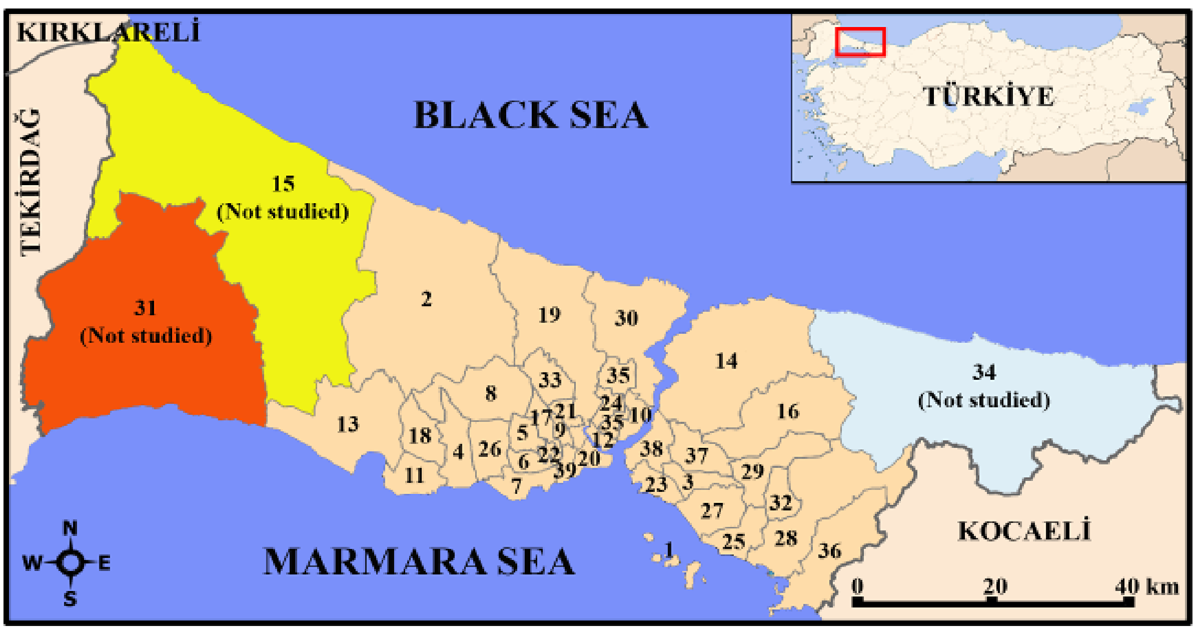

Fig. 1. Districts of Istanbul (Study area). 1. Adalar, 2. Arnavutköy, 3. Ataşehir, 4. Avcılar, 5. Bağcılar, 6. Bahçelievler, 7. Bakırköy, 8. Başakşehir, 9. Bayrampaşa, 10. Beşiktaş, 11. Beylikdüzü, 12. Beyoğlu, 13. Büyükçekmece (not studied), 14. Beykoz, 15. Çatalca (not studied), 16. Çekmeköy, 17. Esenler, 18. Esenyurt, 19. Eyüp, 20. Fatih, 21. Gaziosmanpaşa, 22. Güngören, 23. Kadıköy, 24. Kağıthane, 25. Kartal, 26. Küçükçekmece, 27. Maltepe, 28. Pendik, 29. Sancaktepe, 30. Sarıyer, 31. Silivri, 32. Sultanbeyli, 33. Sultangazi, 34. Şile (not studied), 35. Şişli, 36. Tuzla, 37. Ümraniye, 38. Üsküdar, 39. Zeytinburnu.

The main topographical structure of Istanbul is a low plateau that has approximately 100-200 m elevation. The geological structure contains the Silurian, Devonian, Carboniferous and Tertiary ages originated formations. There are different kinds of rocks and structures that consist of granitic plutons, quartzes, grovacs, clayed schsists and radiolarites (Yaltirik *et al*., 1997; Yasar *et al*., 2010). Although many different soil types are present in Istanbul, the brown forest soil covers the largest area. The non-calcareous brown soil is the second and is suitable for plants. The rendzinas mostly cover the European Side of the city. The alluvial soil also shows distribution in Istanbul (Yaltirik *et al*., 1997; Altay *et al*., 2010b, Yasar *et al*., 2010).

Istanbul is in a kind of transition zone between less rainy Mediterraneal and Oceanic climates. Less precipitation and high temperature are usually observed in the summer. The annual mean temperature was measured as 14.5^{o}C in last two decades. Between May and September, the temperature is generally above 30^{o}C and between November and April; it is rarely below 0^{o}C. In the vegetation period, the daily mean temperature is approximately 8^{o}C and this period is about 280 days (between 15 March and 20 December) (Anon., 2010; Altay *et al*., 2010a; 2010b; Osma *et al*., 2010; Yasar *et al*., 2010).

The total precipitation for Istanbul averages 640 mm per year and 40% of the total precipitation falls in winter. December and January are the most precipitated months. The precipitation ratio in summer is higher than the typical Mediterranean stations hence; this characteristic is related with the Oceanic climate. The minimal rain falls in July and August and its ratio is about 8%. Precipitation is less in spring (about 20-21%), while it increases in autumn (about 28-29%). Additionally, snow rarely falls in Istanbul. The rain regime is Winter-Autumn-Spring-Summer (W.A.Sp.Su) and the rain type is “Central Mediterranean Rain Type” The relative humidity is between 73-77% in the city and these values decrease to 65-68% in summer despite of the effect of the seas. The lower relative humidity, especially in the dry period, forms the xerophytic vegetation. The dominant wind in the city is the Northeast originated wind (Akman & Ketenoglu, 1990; Anon., 2010; Altay *et al*., 2010a; Yasar *et al*., 2010).

Sample collection and preparation: In this study, a total of, 36 of 39 districts of Istanbul (Excluding Çatalca, Silivri and Şile) were visited in both Asian and European sides. Diseased plant samples were collected during the growing periods of 2008-2010, and later transported to Marmara University Faculty of Science and Arts, Department of Biology, Microbiology and Plant Diseases Laboratory.

Identification: Our study was carried out in 36 of 39 different districts (Excluding Çatalca, Silivri and Şile) in both sides (Asian and European) of Istanbul. Plant samples were collected from parks, public and private gardens, road edges, medians and nurseries between the years 2008-2010. Field studies were realized in May, June, July, August and September when cleistothecia were formed. The study area was visited only a few times in April and October. Diseased leaves were first photographed in their natural environment and then put into sterile plastic bags. Each sample was represented by one or more leaves, collected randomly, from plants in each location. Collected fresh samples were dried according to standard herbarium procedures, labeled and put in special envelopes, and then stored in Marmara University, Plant Diseases and Microbiology Laboratory. Some samples were immediately examined with a microscope and some of them were protected for later analysis. Dried leaf samples were moisturized on cheesecloth, which are on Beckers containing boiling water in order to isolate cleistothecia. A water droplet was dropped on the moisturized leaf sample containing cleistothecia and then turned upside down and contacted with a microscope slide and then cleistothecia were investigated. In some plant parts, fungi samples were taken directly using water-soluble glue and fixed on a microscope slide. Water-soluble glue was dissolved in water and cleistothecia, oidiospores, ascospores and mycelia of fungi remained in the slide and then investigated. Diseased specimens were mostly identified by their cleistothecia while non-cleistothecia samples were identified by their oidiospores. 10% KOH was used for dried fungi samples. For identification of the fungi samples “Microfungi on Land Plants and Identification Handbook” (Ellis & Ellis, 1997), “Powdery Mildew Fungi: Classification and Ecology” (Ruhl & Jaslavich, 2002) and “Diseases and Pests of Ornamental Plants” (Pirone, 1978) were used. Olympus CX41 microscope was used for the microscopic diagnoses, and Q-Imaging MicroPublisher 5.0 RTV microscope camera was used for the microscopic pictures.

Results and Discussion

In our study, 43 powdery mildew fungi species were observed on 73 different plant species, which are the members of 11 different genera such as *Blumeria, Leveillula, Erysiphe, Microsphaera, Phyllosticta, Phyllactinia, Sphaerotheca, Uncinula, Oidium, Podosphaera* and *Peronospora* (Fig. 2). Some of these fungi observed on a single plant species were *Erysiphe convolvuli* var. *convolvuli, Erysiphe flexuosa, Erysiphe lagerstroemiae, Erysiphe platani, Erysiphe sparsa, Erysiphe syringae, Erysiphe trina, Erysiphe viburni, Leveillula taurica, Microsphaera alni* var. *vaccinii, Microsphaera alphitoides, Microsphaera berberidicola, Microsphaera diffusa, Microsphaera grossulariae, Microsphaera platani, Microsphaera quercina, Oidium* sp., *Oidium begonia, Oidium euonymi-japonica, Oidium lauraceum, Oidium lini, Peronospora erodii, Phillactinia guttata, Sphaerotheca fusca, Sphaerotheca humuli, Sphaerotheca lanestris, Sphaerotheca macularis, Sphaerotheca pannosa* var. *rosae, Uncinila aceris, Uncinila circinata, Uncinila clintonii, Uncinula geniculata, Uncinila necator, Uncinila parvula, Uncinula salicis.* Among them, *Erysiphe lagerstroemiae* was only observed on *Lagerstroemia indica* and it was found to be effective seriously. Mycelia and oidiospores were densely observed not only on leaves, but also on buds. *Microsphaera platani* has been detected only on plane trees and it was almost seen on every plane tree in Istanbul. Another effective powdery mildew species was *Oidium euonymi-japonica* which was observed on *Euonimus japonica* plants. This fungus covers both upper and lower surfaces of the leaves, buds and even thick young branches as a white colored mass. We also observed that some *Euonimus japonica* plants were weakened by this fungus and died it was also observed that *Sphaerotheca pannosa* var. *rosae*, which was observed on *Rosa* sp., was shown to be effective on these plants and distributed in a wide range in Istanbul.


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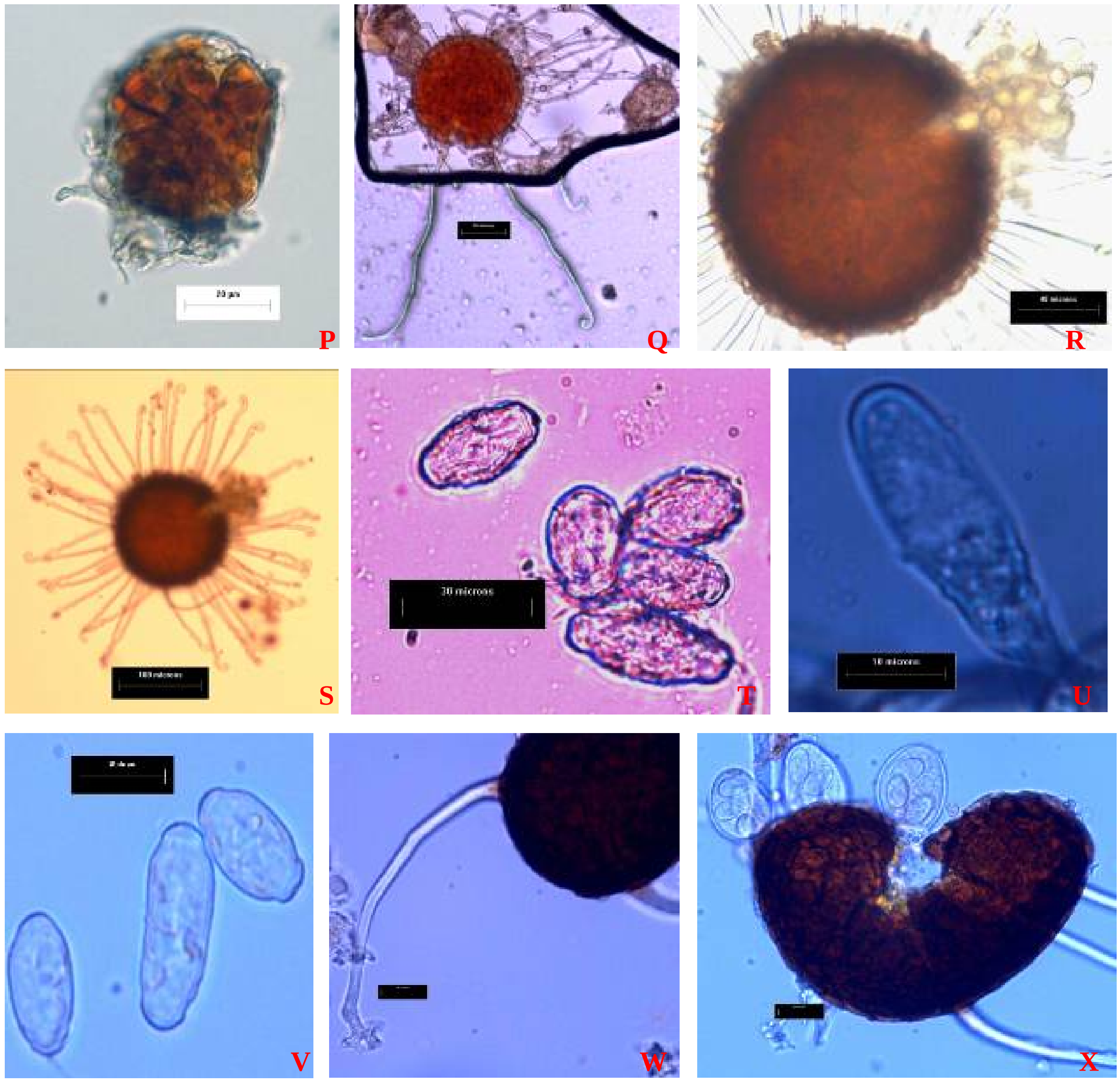

Fig. 2. A-*Microsphaera alni* on *Euonymus japonicus* leaf, B-*Microsphaera alni* on *Quercus robur* leaves, C-*Microsphaera alni* var. *vaccinii* on *Catalpa bignonioides* leaf, D-*Microsphaera alphitoides* on *Quercus cerris* leaf, E-*Microsphaera berberidicola* on *Berberis thunbergii* leaves, F-*Podosphaera leucotricha* on *Cydonia* sp. leaf, G-*Uncinula circinata* on *Acer negundo* leaf, H-*Uncinula necator* on *Vitis vinifera* leaf, I-*Erysiphe convolvuli* var. convolvuli on *Convolvulus arvensis* leaf, J-*Oidium lycopersicum* on *Lycopersicon esculentum* leaf, K-*Microshaera alni* on *Syringa vulgaris* leaves, L-*Erysiphe polygoni* on *Polygonum aviculare* leaves, M-*Podosphaera oxyacanthae* on *Spiraea vanhouttei* leaves, N-*Erysiphe viburni* on *Viburnum tinus* leaves, O-Cleistothecium of *Microsphaera alphitoides* (Bar indicates 40 µm), P-Cleistothecium of *Microsphaera alni* var. *vaccinii* (Bar indicates 20 µm), Q-Cleistothecium of *Uncinula necator* (Bar indicates 50 µm), R-S-Cleistothecium of *Erysiphe flexuosa* (Bars indicate 40 and 100 µm respectively), T-Oidiospores of *Microsphaera alni* (Bar indicates 30 µm), U-Oidiospore of *Oidium lini* (Bar indicates 10 µm), V-Oidiospore of *Phyllactinia corylea* (Bar indicates 20 µm), W-X-Cleistothecium of *Microsphaera alni* var. *vaccinii* (Bars indicate 20 and 40 µm respectively).

In this study, some powdery mildew fungi were cosmopolitan and showed parasitic features for many different plant species. These fungi are *Microsphaera alni* (11 plant species), *Erysiphe polygoni* (9 plant species), *Erysiphe cichoracearum* and *Phyllactinia corylea* (8 plant species). Since these fungi species are harmful for many different plant species, especially agricultural and ornamental plants, they cause economic damage and must be exterminated from the area.

Istanbul has a variable climate and weather conditions and higher temperature, less rainfall and relative humidity and longer summer and autumn conditions will affect the number of powdery mildew fungi and it is certain that increased fungi will increase the amount and variety of diseased plants. Some of the fungi found in the area were seen when the relative humidity was high, while others were seen in higher temperature and less humid seasons. In addition, our study was realized in urbanized areas, especially in parks, public and private gardens, road edges, medians and nurseries, thus, relatively untouched forests and fields were not covered in this study. If the study is to be extended in this way, it is obvious that more fungi and host plants would be found.

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References

Akkurt, M., L. Welter, E. Maul, R. Töpfer and E. Zyprian. 2007. Development of SCAR markers linked to powdery mildew (*Uncinula necator*) resistance in grapevine (*Vitis vinifera* L. and *Vitis* sp.). *Mol. Breeding,* 19: 103-111.

Akman, Y. and O. Ketenoglu. 1987. *Vejetasyon Ekolojisi (Vegetation Ecology).* A.Ü. Fen Fakültesi Yayın No: 146. Ankara, Turkey.

Altay, V., I.I. Ozyigit and C. Yarci. 2010a. Urban flora and ecological characteristics of the Kartal District (Istanbul): A contribution to urban ecology in Turkey. *Sci. Res. Essays*, 5(2): 183-200.

Altay, V., I.I. Ozyigit and C. Yarci. 2010b. Urban ecological characteristics and vascular wall flora on the Anatolian side of Istanbul. *Maejo Int. J. Sci. Technol.*, 4(3): 483-495.

Anonymous. 2010. DMI. The official website of Turkish State Meteorological Service, 2010. http://www.dmi.gov.tr

Carlile, M.J., S.C. Watkinson and G.W. Gooday. 2001. *The Fungi*, 2nd ed. Academic Press, San Diego, CA.

Ellis, M.B. and J.P. Ellis. 1997. *Microfungi on Land Plants and Identification Handbook*, 2nd Ed., The Richmond Publishing Co. Ltd.

Flint, M.L. 1998. *Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide*. Oakland Univ. Calif. Agric. Nat. Res. Publ. 3332.

Jahn, M., H.M. Munger and J.D. McCreight. 2002. Breeding cucurbit crops for powdery mildew resistance. In: *The Powdery Mildews: A Comprehensive Treatise* APS. (Eds.): R.R. Bélanger, W.R. Bushnell, A.J. Dik and T.L. W. Carver . Press, St. Paul, USA, pp. 239-248.

Kaya, S. and P.J. Curran. 2006. Monitoring urban growth on the European side of the Istanbul Metropolitan area: A case study. *Int. J. Appl. Earth Obs. Geoinf.,* 8: 18-25.

Koike, S.T., P. Gladders and A.O. Paulus. 2007. *Vegetable Diseases-A Color Handbook*. Academic Press, San Diego, CA.

Kristkova, E., A. Lebeda and B. Sedlakova. 2009. Species spectra, distribution and host range of cucurbit powdery mildews in the Czech Republic, and in some other European and Middle Eastern countries. *Phytoparasitica*, 37(4): 337-350.

Lebeda, A., E. Křístková, B. Sedláková, J.D. McCreight and M.D. Coffey. 2008. New concept for determination and denomination of pathotypes and races of cucurbit powdery mildew. In: *Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae* Avignon, (Ed.): M. Pitrat. France. pp. 125-134.

Li, X., K. Gasic, B. Cammue, W. Broekaert and S. S. Kobran. 2003. Transgenic rose lines harboring an antimicrobial protein gene, *Ace-AMP1*, demonstrate enhanced resistance to powdery mildew (*Sphaerotheca pannosa*). *Planta*, 218: 226-232.

Luo, P.G., H.Y. Luo, Z.J. Chang, H.Y. Zhang, M. Zhang and Z.L. Ren. 2009. Characterization and chromosomal location of Pm40 in common wheat: a new gene for resistance to powdery mildew derived from *Elytrigia intermedium*. *Theor. Appl. Genet.,* 118: 1059-1064.

Municipality. 2011. The official website of Istanbul Metropolis Municipality. http://www.ibb.gov.tr

Osma, E., I.I. Ozyigit, V. Altay and M. Serin. 2010. Urban vascular flora and ecological characteristics of Kadıköy district, Istanbul, Turkey. *Maejo Int. J. Sci. Technol.*, 4(1): 64-87.

Perugini, L.D., J.P. Murphy, D. Marshall and G. Brown-Guedira. 2008. Pm37, a new broadly effective powdery mildew resistance gene from *Triticum timopheevii*. *Theor. Appl. Genet.*, 116: 417-425.

Pirone, P.P. 1978. *Diseases and Pests of Ornamental Plants*, 5th Ed., John Wiley and Sons, New York.

Rankovic, B. 1997. Hyperparasites of the genus *Ampelomyces* on powdery mildew fungi in Serbia. *Mycopathologia*, 139: 157-164.

Ruhl, G.E. and C.A. Jaslavich. 2002. *Powdery Mildew Fungi: Classification and Ecology*. The Plant Healthy Instructor.

Sztejnberg, A., S. Galpet, S. Mazar and N. Lisker. 1989. *Ampelomyces quisqualis* for biological and integrated control of powdery mildews in Israel. *J. Phytopathol.*, 124: 285-295.

Takamatsu, S., T. Hirata and Y. Sato. 1998. Phylogenetic analysis and predicted secondary structures of the rDNA internal transcribed spacers of the powdery mildew fungi (Erysiphaceae), *Mycoscience*, 39: 441-453.

Tuikapp. 2010. The official web site of Turkish Republic Office of Prime Ministry Statistics Institution. http://tuikapp.tuik.gov.tr

Wan, P., L. Ling, S. Cao, X. Wang, W. Zhang, H. Ling, L. Zhu and X. Zhang. 2007. Isolation, chromosomal location, and expression analysis of putative powdery mildew resistance genes in wheat (*Triticum aestivum* L.). *Euphytica*, 155: 125-133.

Yaltirik, F., A. Efe and A. Uzun. 1997. *Tarih Boyunca İstanbul'un Park, Bahçe ve Koruları Egzotik Ağaç ve Çalıları (The Inventory of Exotic Tree and Bush Species of Istanbul's Parks, Gardens and Groves)*. No. 4, Istanbul Metropolis Municipality, İsfalt Press, Istanbul.

Yasar, U., I.I. Ozyigit and M. Serin. 2010. Judas tree (*Cercis siliquastrum* L. subsp. *siliquastrum*) as a possible biomonitor for Cr, Fe and Ni in Istanbul (Turkey). *Rom. Biotech. Lett.*, 15(1): 4979-4989.

Ypema, H.L., M. Ypema and W.D. Gubler. 1997. Sensitivity of *Uncinula necator* to benomyl, triadimefon, myclobutanil, and fenarimol in California. *Plant Dis.,* 81: 293-297.

Zahavi, T., M. Reuveni, D. Scheglov and S. Lavee. 2001. Effect of grapevine training systems on development of powdery mildew. *Eur. J. Plant Pathol.,* 107: 495-501.

Zhao, T.J., S.Y. Zhao, H.M. Chen, Q.Z. Zhao, Z.M. Hu, B.K. Hou and G.M. Xia. 2006. Transgenic wheat progeny resistant to powdery mildew generated by *Agrobacterium inoculum* to the basal portion of wheat seedling. *Plant Cell Rep.,* 25: 1199-1204.

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