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Journal homepage: asn.shu.bg**Allergenic potential of *Platanus* L. species in urban environment****Rusana Tsvetanova***University of Forestry, Sofia**10 St. Kliment Ohridski Blvd., 1756 Sofia, Bulgaria*

Abstract: *The species of the genus *Platanus* L. are widely used in urban green infrastructure in Bulgaria and abroad, but are proven to be a serious source of allergen pollen emissions. The number of people, affected by pollinosis, is increasing every year and this affects the world economy and health of the population in a high level. The pollen of the plane tree is light, very small and spreads anemophilically. This is one of the genera that produce the largest amount of pollen per inflorescence. This makes *Platanus* a tree of a high allergy potential that has the tendency to get higher in time, because of its increasing use in urban green spaces. The aim of this study is to collect data for allergy potential of the three species of plane tree in some of the European countries, where the allergy is a significant problem, and to compare the sensitization of patients to its pollen in Bulgaria.*

Keywords: pollen allergy, *Platanus*, pollinosis, sensitization, urban environment

Introduction

In recent decades, pollen sensitivity has increased significantly worldwide. According to data, nearly 30% of the world's population is affected by allergenic pollen [1, 2]. More than 150 million people living in cities in Europe suffer from chronic pollen allergy [2, 3]. Between 10-30% of the world's population suffers from allergic rhinitis due to exposure to allergenic pollen [4]. Globally, the most used of the tree species is *Platanus x acerifolia* (Aiton) Willd. [5, 6]. More than 100,000 individuals of this species have been planted in

cities such as New York, London and Sydney [7]. It is widely used in landscaping in urban areas in Bulgaria [8].

An overview of the situation in Europe

In Europe, the tree species that have the most highly allergenic tree pollen belong to the order Fagales. The largest of them is the participation of the family Birch (Betulaceae), Walnut (Juglandaceae) and Beech (Fagaceae). In Betulaceae the most allergenic is the pollen of birch, hornbeam, alder, hazel. In family Fagaceae beech, oak and chestnut are the species with the highest potential [2, 9]. In Europe, hay fever is the most common form of allergy and the number of people affected is increasing every year. This is one of the biggest health problems, significantly affecting the world economy [10, 11].

Plane trees are one of the main causes of allergies in Mediterranean countries, such as Italy [12], Greece [13], Spain [14, 15, 16] and Portugal [17]. *Platanus x acerifolia* is one of the most common tree species with allergenic potential in the Mediterranean region [2].

In Madrid, Spain, the most significant presence of tree pollen in the air (from 1979 to 1993) was that of *Quercus* L. (17%), followed by *Platanus* (15%). In Placencia, Spain, where *Castanea sativa* Mill. is a major source of pollen, it has been shown that of 210 patients with pollen allergy, 36.6% were sensitive to *Platanus x acerifolia* [18].

According to Bicakci & Tosunoglu [19], in Turkey the dominant pollen in the air is mainly tree pollen. The highest amount of plane pollen was measured in Central and Western Turkey and less in Eastern and Northern Turkey. The main species of plane tree in Turkey is the eastern plane - *Platanus orientalis* L., which is naturally distributed. In the central parts of the city, where many plane trees have been planted in recent years. Their pollen is one of the most commonly found in general samples. *Platanus occidentalis* L. and *Platanus x acerifolia* were used as alley and park plantations. Pollen from all three species is one of the most common in large cities. In Turkey during the spring time the most common pollen in the air is that of *Platanus*. In Central Turkey the sensitivity to plane tree pollen is about 0.70-29.10% of the Turkish population [19].

In Greece, the aggregated data show that of the total amount of concentrated pollen, plane trees occupy an average position of about 5.4%. In the period 1990-2001, a total of 1744 patients with a clinical history and sensitivity to pollen were examined in Thessaloniki. Of the sensitized patients, 107 (8.2%) showed allergies to plane trees [20]. Three species of the genus *Platanus* are cultivated in Bulgaria - eastern plane tree (*Pl. orientalis*), western plane tree (*Pl. occidentalis*) and hybrid plane tree (*Pl. x acerifolia*) [21].

An overview of the situation in Bulgaria

Platanus orientalis is naturally distributed in our country and is included in the Red Data Book of the Republic of Bulgaria, item 1. Plants with the category “Rare species” [22]. It is distributed in the southern part of the Balkan Peninsula, and in Bulgaria it is found along rivers and in Eastern Rhodopes up to 1000 m above sea level [21].

At this stage, the data on the allergenic potential of the species of the genus *Platanus* for Sofia are reduced to the study of [23]. Patients showed positive skin allergy tests for B2III Group tree pollen, in which eastern plane pollen was present, as follows, 30 patients (21%) showed hypersensitivity to all three group tree pollen allergens (B2I, B2II and B2III), and most positive skin allergy tests are rare - only to B2II or B2III tree mix.

In Bulgaria, the impact of the allergenic potential of plane trees has not yet been studied and there are partial current data on the quantitative participation of members of the genus in public green data [24, 25]. The only functioning aerobiological station to date is located in Sofia, the capital of Bulgaria.

According to aerological studies by Nikolov et al. [23] in Bulgaria, tree pollen accounts 81-83% of the total number of pollen in the air. The most significant influence is exerted by those of the family Betulaceae, which form a significant amount of pollen. Among them, birch ranks first, producing 45-76% of the whole family. Nikolov et al. [23] concluded that tree pollen is the main reason for the appearance and development of respiratory allergy in many sensitized Bulgarians.

Advantages of *Platanus x acerifolia*

Along with their high decorative qualities, plane trees are valued for their tolerance to contamination, which is due to the morphological features of its leaves [26, 27], thanks to which its particle capture capacity from the air is very high. Leaf hairs have been shown to effectively trap ferromagnetic particles [28]. *Platanus x acerifolia* has the ability to accumulate contaminants in its bark [29]. Species of this genus actively influence the microclimate in urban environments with their wide crown, which provides shade on hot summer days. Its high phenotypic plasticity allows it to adapt well in different conditions and be implemented in cities with different climatic characteristics [5, 7].

Disadvantages of *Platanus x acerifolia*

Along with its positive qualities, it is also one of the tree species that causes serious respiratory symptoms due to the formation and emission of a huge amount of pollen containing Pla a 1-3 allergens [15, 30]. One of the important characteristics of *Platanus x acerifolia* is that it is one of the main species that emit monoterpenes and sesquiterpenes [31] involved in ozone formation [32].

Platanus x acerifolia is used in many alley and park plantations in Central and Southern Europe, and the number of people who are sensitive to it is increasing (in Spain between 8-9% in northern cities and 52-56% in Madrid). Studies in Spain have reported several peaks of pollen allergies associated with an increase in the number of pollens per cubic meter of air. The strongest was on March 29, 2017, when 1549 pollen grains per cubic meter were detected. The peaks are invariably related to the amount of precipitation, which was then significant, as well as the temperature drop to 17 °C. After conducting research over a period of two years (2017 and 2018), it was found that plane and alder are the species with the highest number of days with an average potential risk of allergies (a total of 22-27 days for both years). Also, plane, along with birch, have the most days (30-31 days) in total for the two years with a high average amount of wind-borne pollen [33].

It has been proven that at a distance of over 400 m the concentration of pollen grains in the air decreases significantly [34].

With a tree density of 100 to 300 pcs / sq. km in an urban environment, the annual amounts of pollen can vary from several hundred to several thousand depending on the above conditions, as well as the proximity of the traps to the sources of pollen [34].

As early as 1970, plane trees were shown to cause sensitization [35]. *Platanus* pollen is a serious cause of asthma, allergic rhinitis and conjunctivitis [36, 37]. Between plane tree pollen and different types of food often occurs strong cross-reactivity [38, 39].

Plane trees bloom in the spring and produce a significant amount of pollen [6]. Their pollen spreads rapidly, anemophilically and over long distances, and the eastern plane tree has been found to be one of the species with the largest amount of pollen in the inflorescence: $3.3 \times 10^6 \pm 0.2 \times 10^6$ [40]. Older trees, due to the larger and wider crown, form a lot more pollen than young individuals [41, 42]. Some patients also report symptoms during the months of September and October, which can be explained by the movement of pollen attached to the leaves during their fall [43].

Cariñanos et al. [44] emphasizes that the benefits of using plane trees in urban landscaping are indisputable, but the negative effects of this must also be assessed so as not to upset the balance between the ecosystem services provided by species on the one hand and the negative impact on the environment.

Influence of other factors

Changes in climate are having a serious impact on pollen production and distribution. With warming, a different atmospheric circulation over Europe is manifested, which leads to a longer transport of allergenic pollen. This in turn increases the risk of sensitizing people sensitive to pollen. Climate change directly affects the amount of pollen produced, the degree of allergenicity, the length of the pollen season, the distribution of

plants and their pollen [45]. There has been an increase in the number of cases in which climate change leads to the rapid and trouble-free migration of allergenic species to new latitudes [9, 46].

Due to climate changes the average monthly and annual temperatures are raising, the vegetation boundaries are moving north. The plants grow much more intensively and for a long time, therefore the pollination season is prolonged. All of these effects may be most noticeable in regions where the greatest impact of climate change is expected, such as the Mediterranean basin, which is classified as one of the most vulnerable regions to climate change in the world due to the projected increase in climate change. temperature and significant reduction in precipitation [44]. Thunderstorms also have a large impact because osmotic shock causes the pollen shell to rupture and allergen particles to disperse [9, 47].

Unfortunately, nowadays tree pollen does not affect people in its pure form. Modern man is placed in a complex situation due to another very important factor that is associated with industrialization in cities - air pollution and the environment. Given certain concentrations of air pollutants, pollen grains may undergo physicochemical surface changes, increasing the fragility of exine [48], modifying the total protein and allergen content [49], altering reproductive functions (particularly viability and / or germination) [50] and altering the allergenic potential that results in a more intense allergic response in susceptible patients [51, 44].

Polluted urban environment and air contribute to the deterioration of the condition of sensitive patients. [52, 53]. It has been found that in Europe 20% of the population is sensitive to plant pollen Type 1 [54], which is more pronounced in urban areas and relatively weaker in rural areas [55, 56]. One of the reasons that may be due to this is the formation of the so-called 'heat islands' [57]. The effect of these is an earlier onset and a significantly longer pollen season [58]. Air pollutants, which cause an increase in plant biomass, as well as the amount of protein in pollen grains, which causes allergies, are also of great importance and influence [59].

Cariñanos et al. [44] examines the effect that urban environmental conditions and air pollutants have on plane pollen emissions in Granada. It is a city with a Mediterranean climate and one of the most polluted in Spain. Granada is one of the Mediterranean cities where the increase in the percentage of the population affected by allergies to plane pollen in recent decades is most significant. One of the most common tree species there is *Platanus x acerifolia* (*Pl. x. hispanica*). It is represented by as much as 14.5% of the total number of trees in the city, part of all green spaces - historic gardens, large parks, street landscaping, alley networks, road infrastructure and more.

The collected statistics for plane pollen from 1992 to 2019 establish the main trends in aerobiological parameters and the relationship with meteorological variables, air dust and gaseous air pollutants, both before and during the flowering period. The average seasonal pollen integral (SPIn) of about 2700 pollen grains per cubic meter showed a significant increase throughout the study period. This increase in allergen emissions may be related to an increase in crown volume, tree growth, but also other environmental factors. Precipitation

and minimum temperatures in the winter before flowering are the parameters that have shown the greatest impact on SPIn, while O₃ and NO_x are the pollutants that have the greatest effect on the peak value. The strong dependence of the pollen grains on the strength, speed and direction of the wind has been proven. It helps to spread pollen grains faster in urban environments and to transfer the highest quality pollen emissions from mature individuals from the periphery to the center. This leads to greater aggravation of the situation in pollen-sensitive patients [44].

Causes of allergies

The main allergen of plane - Pla a1 [60] - turns out to be independent of the amount of plane pollen that exists during the flowering period. Even after the disappearance of pollen, Pla a1 continues to exist in the atmosphere and thus prolongs the risk period for the development of allergies. This is especially true for the rainy season, which helps release allergens [16]. The 43 kDa protein has been shown to be identified as a Pla 2 pollen allergen. Pla a 1 is found in up to 92% of patients monosensitized to *Platanus x acerifolia* and in 83% of polysensitized patients [61]. Pla a 2 is involved in allergic reactions in 84% of patients with pollen allergy and represents 52% of the total IgE-binding capacity of plantain extract [62]. In the Mediterranean region, Pla a 3 is a minor allergen (27.3%) in patients with pollen allergy who do not have a food allergy and a major allergen (63.8%) in patients allergic to plane trees with peach allergy [63].

Studies on the interaction of *Platanus x acerifolia* with food causing allergies show that of the 720 patients studied with respiratory problems and proven food allergies, only 61 (8.48%) responded to plane pollen. Of these, 32 (52.45%) were found to have a reaction to food allergens such as: hazelnuts, apples, peaches, peanuts, lettuce and others [64].

Conclusion

The significant increase in the number of individuals of the genus *Platanus*, used for landscaping in urban areas in our country, requires research to be conducted on their participation in the general pollen allergen background and their impact on the health of Bulgarian citizens. Over the years, plane pollen in the air is expected to increase many times, which is likely to create a precondition for sensitization of patients with hay fever.

In this regard, it is necessary to determine the allergenic potential of plane species in Bulgaria. To this end, the following tasks must be performed:

1. Establishment of the quantitative and qualitative (according to biometric indicators) participation of the three species of the genus *Platanus*, used in the green urban areas in our country, as well as the naturally distributed ones;

2. Determining the total area and the density of plane planting in (separate massifs and single plantations) all urban green spaces, gardens, parks, squares, street and alley landscaping.

3. Establishment of the flowering period of the three species, by phenological observations and aerobiological measurements;

4. Addressing the factors of the urban microclimate - temperature, precipitation, humidity, wind, as well as air pollution.

5. Production and testing of allergenic preparations with pollen from the three species of plane trees on patients with pollinosis.

The establishment of the allergenic potential of the species of the genus *Platanus* L. at the moment in our country and the forecast for its future change will provide guidelines for risk assessment of the use of these species in landscaping. The obtained results will provide guidelines for the design of sustainable green areas with low risk of allergies. The results of this interdisciplinary study are important both for clinical allergologists and for landscape architects and ecologists involved in the planning and management of urban green infrastructure.

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