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Adaptability of indigenous vegetation on parking lots – A case study: Tree alleys in Novi Sad, Serbia

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Abstract

In this study five indigenous species on parking lots in Novi Sad, Serbia were examined (*Acer platanoides* 'Globosum', *Celtis australis* L., *Tilia tomentosa* Moench., *Carpinus betulus* 'Fastigiata', and *Corylus colurna* L.). The aim of this study is to represent their adaptability to urban stress and harsh environmental conditions which are present on parking lots by valuing their dimensions and vitality. Results showed that well-adapted species are *Celtis australis* L. and *Carpinus betulus* 'Fastigiata'. Other species had low vitality values, asymmetrical canopy, and mechanical damages that were caused by insufficient root and canopy space and insufficient distance from buildings and traffic. Choosing well-adapted indigenous species for alleys can be very challenging. Adaptability assessment of indigenous trees on parking lots in Novi Sad can be used as guidance to urban planning in Novi Sad and other cities which have a high share of pavement to reduce the climate change effect.

Key words: alley, indigenous vegetation, parking lots, street trees, urban stress

Introduction

In the last few decades, a lot of attention has been paid to studying the adaptability of woody taxa within secondary populations in urban areas. Changing environmental conditions due to soil and air pollution, excess heat, strong winds, and shading by surrounding buildings negatively affect the growth rate, survival, vitality, and functionality of urban trees (Sand et al., 2018; Hus et

al., 2021). In order to provide climate regulation, aesthetical, and recreational value, street trees need to bear many stress factors caused by urbanization such as impervious surface located near trees (Sand et al., 2018). Proximity of impervious surfaces, such as pavement, can negatively influence water availability, vitality, and growth of urban trees (Konarska et al., 2015). Therefore, the biggest challenge is the adaptation of woody taxa to the conditions prevailing in localities that have a high share of paved area. High share of impermeable paved surfaces around tree individuals in urban areas enhances soil and air temperatures, enables root and canopy development, and affects biological processes like the blooming phenophase which can be influenced by the urban heat island effect (Đorđević et al., 2021). Besides biological processes, the increase of paved surfaces and traffic proximity, as a consequence of urbanization can affect dimensions and vitality value of urban trees (Kostić et al., 2017) and reduce their uniformity. Taxa that do not have the ability to adapt to changed conditions of the urban environment become more susceptible to disease development and pest attack. Trees planted near pavement often suffer due to root damage and soil volume restriction and cause sidewalks to crack and heave (Appleton et al., 2009).

Typical parking lot design implies impervious material like asphalt. Erosion, heat island effect, flooding, and surface water pollution increase as a result of that kind of paving. These issues can be alleviated by adding tree canopies to parking areas that would provide additional benefits (Simonds, 2018). Planting trees on parking lots which are usually highly paved surfaces can bring many benefits such as improvement of appearance, prevention of soil erosion, reduction of carbon dioxide, wind, noise, storm water drainage problems and provision of shade as an enhancement of human comfort. However, the stress of compaction and low soil fertility, coupled with other physical, environmental, and human factors on paved surfaces affects trees, so selecting appropriate trees for parking lots and other paved areas is challenging (Appleton et al., 2009).

Although urban flora consists of indigenous and non-indigenous species, urbanization can be a bigger threat for native species (Garrard et al., 2018) affecting their habitat and thus making them more vulnerable to climate change. Many native trees in urban areas are growing under harsh environmental conditions due to climate change which leads to decreasing vitality and increasing mortality risk (Roloff et al., 2018). Although most non-indigenous species have successfully adapted to the changed environmental conditions, preference should be given to the use of indigenous species in green areas in order to preserve biodiversity within an urban environment. Local trees support the wider ecosystem, so native biodiversity is a key to resilience and it makes the best habitat (Simonds, 2018). The key to their better adaptation in urban areas is careful selection of plants and planting sites, good care of seedlings, providing

of sufficient space for the root system and canopy development, more green and permeable surfaces with the usage of landscape pavers instead of solid asphalt or concrete (Appleton et al., 2009; Đorđević et al., 2021). Choosing high adaptive urban tree species to urban stress and climate change is an effective way to reduce climate change impacts (Liu et al., 2021). The selection of resistant taxa to stressful conditions of the urban environment leads to the creation of a more favourable microclimate, a more pleasant environment, and the inclusion of tree seedlings in parking lots in the city's green system.

The aim of this study is to explore the adaptability of five indigenous tree alleys species located on parking plots (*Acer platanoides* 'Globosum', *Celtis australis* L., *Corylus colurna* L., *Tilia tomentosa* Moench., and *Carpinus betulus* 'Fastigiata') to paved surface and traffic proximity by measuring their dimensions and vitality characteristics as potential indicators of their adaptability.

Material and Methods

Study area

The analysis included 200 indigenous tree individuals (10 individuals of *Acer platanoides* 'Globosum', 118 of *Celtis australis* L., 28 of *Tilia tomentosa* Moench., 25 individuals of *Carpinus betulus* 'Fastigiata', and 19 individuals of *Corylus colurna* L.), out of which 101 are located on green strips and 99 are located on paved surface in 9 streets in Novi Sad. The analysed area is at an average altitude of 72-80 m a.s.l. The climate is temperate continental to modified continental, fully humid with warm summers, according to the Köppen-Geiger climate classification (Kottek et al., 2006). Alleys are located beside or in between parking lots in the settlements of Podbara and Stari Grad, which are dense and highly paved areas of Novi Sad under the influence of the urban heat island effect (Savić et al., 2018). *Acer platanoides* 'Globosum' is located in Stevana Musića Street, *Celtis australis* L. in Radnička and Sonje Marinković Street, *Tilia tomentosa* Moench. in Maksima Gorkog Street, *Carpinus betulus* 'Fastigiata' in Ise Bajić, Ilije Ognjanovića, and Episkopa Visariona Street, and *Corylus colurna* L. in Marka Miljanova Street and Belgrade Quay (Fig. 1).

Fig. 1. Location of the study area and location of analysed alleys (1 - *Acer platanoides* 'Globosum', 2 - *Celtis australis* L., 3 - *Tilia tomentosa* Moench., 4 - *Carpinus betulus* 'Fastigiata', 5 - *Corylus colurna* L.)

Data analysis

Parameters included paving type (green strip or pavement), width around the opening around the tree (WAOT) if the individual is located on the pavement, width of green strips (WGS) if the individual is located on a green strip, distance from the centre of the individual to traffic (D), height (H), height to first branch (HFB), diameter at breast height (DBH), crown width (CW), dry branches (DB), mechanical damages (MD), phytopathological and entomological damages (PED), vitality (VIT), and decorative value (DEC). These parameters were scored from 1 (poor) to 5 (excellent), according to the generally accepted methodology of urban forestry evaluation valorised by two persons (Mattheck et al., 1993). Collected data were statistically processed using STATISTICA 13 software (DELL, USA). Descriptive statistics were analysed with calculating mean, standard error, and coefficient of variation (Hadživuković, 1991).

Results and Discussion

Based on the results (Tab. 1) we notice that species *Celtis australis* L. and *Carpinus betulus* 'Fastigiata' stand out from other species by their high vitality (4,55/5 and 4,4/5) (Fig. 2) and decorative value (4,4/5 and 4,0/5). The lowest vitality and decorative value has been found in *Corylus colurna* L. (3/5 and 2.9/5) because most individuals have asymmetrical canopy with dry branches, bent trunk, and mechanical damages.

Tab. 1. Mean values ± standard error and variability coefficient of the observed species (H – height (m), HFB – height to first branch (m), DBH – diameter at breast height (cm), CW – crown width (m), VIT – vitality value (1-5), DEC – decorative value (1-5))

	Acer platanoides 'Globosum'	*Celtis australis* L.	*Tilia tomentosa* Moench.	*Carpinus betulus* 'Fastigiata'	*Corylus colurna* L.
H (m)	4.8 ± 0.57 (0.38)	11.3 ± 0.57 (0.4)	8.9 ± 0.5 (0.3)	5.7 ± 0.27 (0.23)	9.8 ± 0.55 (0.24)
HFB (m)	2.1 ± 0.16 (0.24)	2.75 ± 0.2 (0.52)	2.3 ± 0.13 (0.3)	0.7 ± 0.36 (2.7)	2.6 ± 0.15 (0.25)
DBH (cm)	15.4 ± 1.29 (0.26)	52.5 ± 3.8 (0.56)	25.9 ± 2.54 (0.52)	7.9 ± 0.59 (0.37)	30.2 ± 2.83 (0.41)
CW (m)	4.3 ± 0.62 (0.46)	5.7 ± 0.2 (0.33)	6 ± 0.43 (0.38)	2.7 ± 0.29 (0.49)	6.9 ± 0.51 (0.32)
VIT (1-5)	3.9 ± 0.17 (0.14)	4.55 ± 0.08 (0.13)	3.5 ± 0.11 (0.16)	4.4 ± 0.13 (0.13)	3 ± 0.17 (0.25)
DEC (1-5)	3.6 ± 0.21 (0.18)	4.4 ± 0.1 (0.17)	3.25 ± 0.12 (0.2)	4 ± 0.1 (0.11)	2.9 ± 0.14 (0.21)

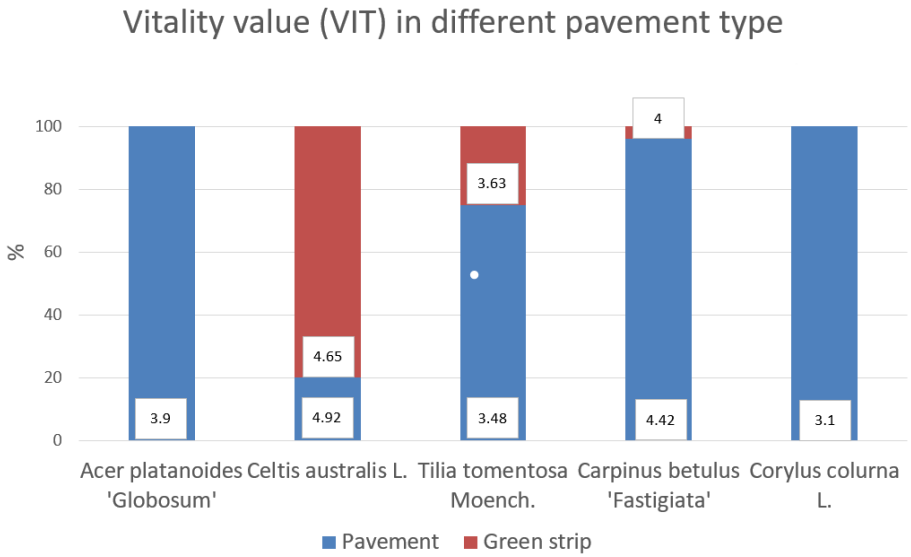

Fig. 2. Vitality values with the green strip – pavement ratio of five examined species

Asymmetrical canopy was also noticed on *Tilia tomentosa* Moench. and *Acer platanoides* 'Globosum', which has the narrowest space for root development (average 68 cm) and is insufficiently distant from nearby buildings. Mechanical damages have been noticed on most individuals regardless of species which indicates that the proximity of traffic and human factor threatens the

vitality of the observed species (Fig. 3). No significant phytopathological and enthomological damages were found. In the study area we have noticed that, besides affecting tree dimensions, insufficient root and canopy space, present mainly on old species like *Celtis australis* L., lift and curve the sidewalk.

Fig. 3. Insufficient root space and asymmetrical canopy of *Acer platanoides* 'Globosum', insufficient distance from buildings of *Celtis australis* L., insufficient root space and compaction of soil of *Tilia tomentosa* Moench., mechanical damages of *Carpinus betulus* 'Fastigiata' and bent trunk, asymmetrical canopy and low decorative value of *Corylus colurna* L.

Adaptability of indigenous species to harsh environmental conditions was the subject of many authors. Authors Kostić et al. (2018) in Novi Sad, on the example of *Acer pseudoplatanus* L. which is also an indigenous species, revealed that paved surroundings had the most significant effect on tree dimensions and less on vitality which is in line with our results. Also, the same authors noted that the distance from the traffic has a stronger influence than the width of landscape strip on which the individual is located. Impermeable surface, compaction and low soil fertility, air and soil pollution, proximity of traffic and buildings and insufficient sunlight noticed in the study area affect the vitality of trees. Using the examples of linden trees in Gothenburg, Sand et al. (2018) concluded that the use of permeable surface materials is beneficial for the vitality and growth of urban trees planted along streets in other cities, so the use of permeable landscape pavers instead of solid asphalt or concrete should be considered in future parking plots design. Even though indigenous species were chosen as a subject for this study, plant selection can also be challenging in terms of using introduced species. Thus, our future study will be directed towards examining the

adaptability of introduced species on parking lots and comparing whether they are more resistant or also sensitive to harsh environmental conditions on parking lots like indigenous species.

Conclusion

By measuring dimension characteristics and vitality values of five indigenous tree species on parking lots in Novi Sad, the results have shown that the most adapted species to harsh environmental conditions with the highest vitality value are *Celtis australis* L. and *Carpinus betulus* 'Fastigiata', followed by *Acer platanoides* 'Globosum' and *Tilia tomentosa* Moench. The lowest vitality and decorative value has been found in *Corylus colurna* L. with a bent trunk, asymmetrical canopy, dry branches, and mechanical damages. Due to many factors like impermeable surface, traffic and buildings proximity, insufficient root and canopy space, insufficient light, dense planting, measures of care and protection and human factor, most of the examined individuals had asymmetrical canopy. We can conclude that indigenous species can be used in tree alleys on parking lots, but need to have good growth and development conditions. Asphalt or concrete parking lots should be replaced with heat and water permeable surfaces, plants should be planted at a sufficient distance from buildings, traffic, and other individuals so that they can fulfil their growth potential, ecological, and aesthetical role.

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Адаптабилност аутохтоне вегетације на паркинг просторима. Студија случаја: Дрвореди у Новом Саду, Србија

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Сажетак

У раду је испитивано пет аутохтоних дендролошких врста на паркинг просторима у Новом Саду, Србија (*Acer platanoides* 'Globosum', *Celtis australis* L., *Tilia tomentosa* Moench., *Carpinus betulus* 'Fastigiata' и *Corylus colurna* L.). Циљ рада је да се вредновањем димензија и виталности прикаже прилагодљивост одабраних јединки урбаном стресу и тешким условима животне средине који су присутни на паркинг просторима. Резултати указују да су се таксони *Celtis australis* L. и *Carpinus betulus* 'Fastigiata' добро прилагодили испитиваним условима. Остале врсте су имале ниске вриједности за виталност, асиметричне крошње и механичка оштећења која су настала услед недовољног простора за развој коријена и крошње као и недовољне удаљености од објеката и саобраћајнице. Одабир добро прилагођених аутохтоних врста за улично озелењавање може бити веома изазован, те процјена прилагодљивости аутохтоног дрвећа на паркинг просторима у Новом Саду се може користити као смјерница за урбанистичко планирање у Новом Саду и другим градовима који имају велики удио коловоза, а све у циљу ублажавања посљедица климатских промјена.

Кључне ријечи: дрворед, аутохтона вегетација, паркинг, улично дрвеће, урбани стрес

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