Ornamental Horticulture
ISSN 2447-536X | HTTPS://ORNAMENTALHORTICULTURE.EMNUVENS.COM.BR/RBHO
SBFPO Sociedade Brasileira de Floricultura e Plantas Ornamentais

Scientific Article

Performance of native species in urban afforestation of public pathways in Lavras-MG, Brazil

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Abstract

In addition to creating scenic landscapes and beautifying urban areas, the cultivation of trees in urban areas can benefit ecosystems and improve cities sustainability. Besides some indications of adequate species for use in public pathways, there are few studies and knowledge regarding the native species behavior and uses for this purpose. In this way, the objective of this study was to evaluate the performance of some native species in urban afforestation of public pathways. Species to be evaluated were selected considering characteristics such as occurrence (biome and region), height (medium or high size), growth rate (moderate to fast), and flowering (season and color) and at the end, 11 species were selected. The species *Senna macranthera*, *Andira fraxinifolia*, *Pterocarpus violaceus*, *Cordia superba*, *Jacaranda cuspidifolia*, *Peltophorum dubium*, *Inga vera*, *Inga edulis*, *Senna multijuga*, *Handroanthus impetiginosus* and *Stifftia chrysantha* were planted on a public pathway at Lavras-MG, Brazil (Biome: Mata Atlântica) and evaluated observing the initial survival, growth rate, canopy, diameter at breast height (DBH) and occurrence of damage and disease. Concerning the tested species, *A. fraxinifolia* and *S. macranthera* exhibited low survival after planting (10 months) and must be replaced for other species. *Handroanthus impetiginosus* and *P. violaceus* exhibited the best performance, presenting a good growth rate, followed by *J. cuspidifolia*, *I. vera,* and *I. edulis.*

Keywords: green areas, native trees, urban forest, rban trees development.

Resumo

Desempenho de espécies nativas na arborização de vias públicas – estudo de caso em Lavras-MG, Brasil

Além de criar paisagens cênicas e embelezar áreas urbanas, o cultivo de árvores em áreas urbanas pode beneficiar os ecossistemas e melhorar a sustentabilidade das cidades. Além de algumas indicações de espécies adequadas para uso em vias públicas, existem poucos estudos e conhecimentos sobre o comportamento das espécies nativas e usos para este fim. Desta forma, o objetivo foi avaliar o desempenho de algumas espécies nativas na arborização urbana de vias públicas. As espécies a serem avaliadas foram selecionadas considerando características como ocorrência (bioma e região), altura (tamanho médio ou alto), taxa de crescimento (moderado a rápido) e floração (estação e cor) sendo ao final foram selecionadas 11 espécies. As espécies *Senna macranthera, Andira fraxinifolia, Pterocarpus violaceus, Cordia superba, Jacaranda cuspidifolia, Peltophorum dubium, Inga vera, Inga edulis, Senna multijuga, Handroanthus impetiginosus* e *Stifftia chrysantha* foram plantadas em via pública em Lavras-MG, Brasil (Bioma: Mata Atlântica) e avaliados observando a sobrevivência inicial, taxa de crescimento, copa, diâmetro à altura do peito (DAP) e ocorrência de danos e doenças. Em relação às espécies testadas, *A. fraxinifolia* e *S. macranthera* apresentaram baixa sobrevivência após o plantio (10 meses) e precisaram ser substituídas por outras espécies. *Handroanthus impetiginosus* e *P. violaceus* apresentaram o melhor desempenho, com boa taxa de crescimento, seguidos por *J. cuspidifolia*, *I. vera* e *I. edulis*.

Palavras-chave: arborização urbana, áreas verdes, árvores nativas, desenvolvimento de árvores urbanas.

Introduction

The presence of trees in an urban environment not only provides aesthetic quality and shade but also enhances ecosystem services such as carbon sequestration, improving air quality, increased soil water infiltration, thermal comfort and other benefits (Rahman et al., 2017; Revelli and Porporato, 2018; Sicard et al., 2018)associated with some million deaths worldwide per year. Cities have to cope with the challenges due to poor air quality impacting human health and citizen well-being. According to an analysis in the framework of this study, the annual mean concentrations of tropospheric ozone (O_3). Heat islands are common in urban areas, so the shade provided by trees is the primary factor for pedestrian thermal comfort (Li et al., 2018). The presence of vegetation elements, particularly

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https://doi.org/10.1590/2447-536X.v28i2.2408
Received: June 16, 2021 | Accepted: Jan 06, 2022 | Available online: Feb14, 2022

Area Editor: Joelmir Marques da Silva

trees, is considered the primary component in mitigating the effects of climate change and heat islands in urban centers, where temperatures may be as much as 8 °C higher (Soltani and Sharifi, 2017).

Thus, incorporating more trees in urban environments is a great challenge for public administration that pursue sustainable urban planning, improving environmental conditions for the inhabitants. But in some situations, planning and maintenance of the trees are not satisfactory and, therefore, trees interfere negatively with other urban components (CEMIG, 2011; Oliveira et al., 2018). To minimize conflicts, it is important to perform a rightly selection of the species and a good plantation planning.

In Brazil, identifying trees for planting along pathways is frequently performed by technicians, based on the manuals prepared by energy companies or municipal administration. Selection of tree species requires the observation of characteristics as for example, tree height, canopy, different flowering and fruiting season, pleasant aromas, pests and diseases resistance (CEMIG, 2011) based on research results (Paiva et al., 2004; Berolini et al., 2015; Silva et al., 2016; Costa et al., 2017; Oliveira et al., 2018; Freire and Mussi-Dias, 2019). However, many of the species indicated in manuals as adequate for cultivation on public pathways are shrubs and not trees, such as *Murraya paniculata* (L.) Jack, *Caesalpinia pulcherrima* (L.) Sw, *Lagerstroemia indica* L.*,* and hibiscus *Hibiscus rosa-sinensis* L. These species do not produce intense shade and besides of this, are exotic. The recommendation is because such smaller species present satisfactory size for planting under electrical wiring.

Due to the traditional use of some species and the limited knowledge about the behavior of native species, exotic species are most commonly used in urban afforestation (Almas and Conway, 2016, Costa et al., 2017; Oliveira et al., 2018; Lima Neto et al., 2021). The urban tree forest within many Brazilian cities is composed of more than 50% exotic species, besides naturalized and cultivated (Paiva et al., 2004; Cupertino and Eisenlohr, 2013; Saiter et al., 2015; Costa et al., 2017; Guilherme et al., 2018, Pereira et al., 2020).

The primary advantages of using native species include better adaptation, greater resistance to pests and diseases, and maintenance of the local ecosystem via the preservation of the native fauna and flora in each region (Stumpf et al., 2015). The use of native species in urban afforestation is also important for biological conservation (Stumpf et al., 2015). However, some difficulties using native trees in urban afforestation were observed, such as reducing or nonexistent availability of seedlings for commercialization, and lack of knowledge to identify species that should be used for this purpose (Almas and Conway, 2016, Mello and Pastore, 2020).

Urban afforestation using native species is, in many situations, conducted empirically, without foundation or technical-scientific knowledge. Previous studies are typically restricted to qualitative and quantitative analyses of the existing vegetation (Assis and Paulo, 2013; Fernandes et al., 2018; Boldrin et al., 2019, Freire and Mussi-Dias, 2019)

Also, there are some studies concerning native plants characteristics and uses on forests and reforestation, parks, gardens but not a reduce information for uses in pathways (Biondi and Leal, 2009; Biondi and Leal, 2010). Considering the lack of information and identification of native species for public pathway afforestation, and the need to have data from practical evaluations of these species' development, the objective of this study was to evaluate the performance of some Brazilian native species cultivated in public pathway.

Materials and Methods

The selected place for tree cultivation was the public pathway of the Federal University of Lavras (Universidade Federal de Lavras - UFLA), located in the city of Lavras, Minas Gerais, Brazil. The site is located at coordinates 21°13'32.8"S, 44°58'41.0"W, 918 m altitude, with a Cwa climate, according to the Köppen classification. The predominant forest formation in Lavras is a semideciduous seasonal montane forest, characterized by areas of campo (grassland), campo rupestre (rocky grassland) and cerrado (savanna) vegetation (Carvalho and Scolforo, 2008).

The pathway was next to an avenue with two 7.0 m wide lanes, separated by a 0.60-m wide central bed where lampposts are located. The roadside has a total width of 6.15 m and is divided into a 2.0 m bike lane, a 1.5-m tree bed, a 2.0-m pedestrian sidewalk and a narrow 0.65-m grass bed (Figure 1).

Species selection

The selected species belong to four botanical families, Fabaceae (7), Bignoniaceae (1), Boraginaceae (1), and Asteraceae (1). Also, the biome and the region where the species were originated was considered, avoiding those from distant latitudes considering the experimental area (Table 1).

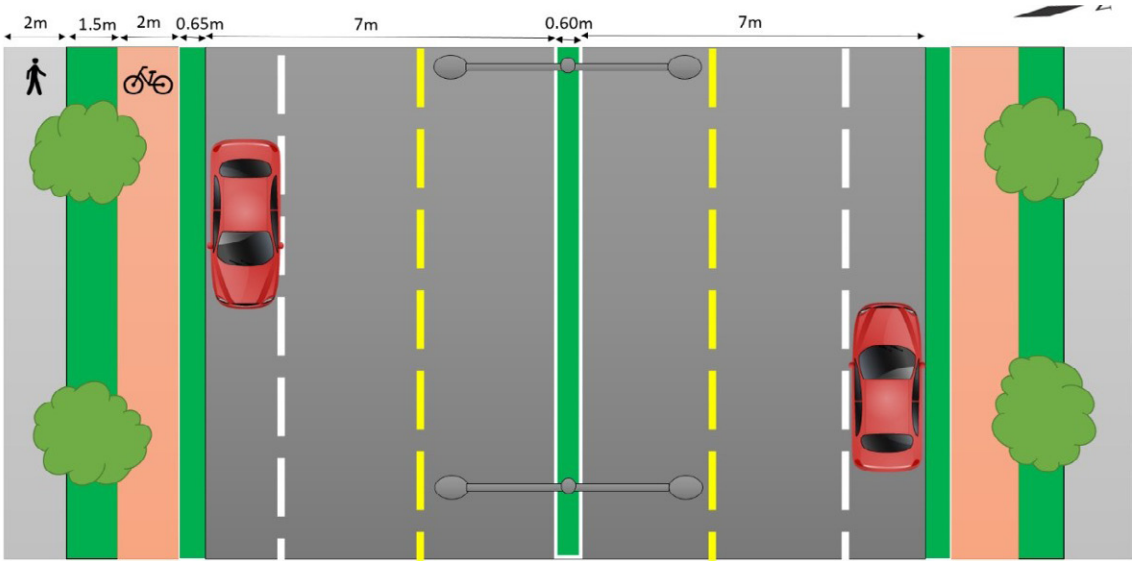

Figure 1. Representation of the avenue where afforestation was conducted and species were evaluated.

Table 1. List, classification, biome and region of origin from the selected tree species.

Family	Scientific name	Common name	Biome	Occurence
Asteraceae	*Stifftia chrysantha* J. C. Mikan	Esponja-de-ouro	Cerrado, Atlantic Rainforest	SE; NE; S
Bignoniaceae	*Handroanthus impetiginosus* (Mart. *ex* DC) Mattos	Ipê-roxo	Cerrado	SE; NE; CW; N (AC, RO, MA)
Bignoniaceae	*Jacaranda cuspidifolia* Mart.	Caroba	Cerrado	SE (MG, SP); CW (MS, MT, GO)
Boraginaceae	*Cordia superba* Cham.	Babosa-branca	Atlantic Rainforest, Caatinga, Cerrado	SE; NE; S (PR); CW (GO, TO)
Fabaceae (Caesalpinioideae)	*Peltophorum dubium* (Spreng.) Taub.	Canafístula	Caatinga, Cerrado, Atlantic Rainforest, Pantanal	NE (BA); SE (MG, RJ); CW (GO, MS); S (PR)
Fabaceae (Caesalpinioideae)	*Senna macranthera* (DC. *ex* Collad.) HS Irwin & Barneby	Aleluia	Caatinga, Cerrado Atlantic Rainforest	SE; NE; S (PR); CW (GO, TO, MT)
Fabaceae (Caesalpinioideae)	*Senna multijuga* (Rich.) H.S. Irwin & Barneby	Pau-cigarra	Amazônia, Caatinga, Cerrado, Atlantic Rainforest	BR
Fabaceae (Mimosoideae)	*Inga edulis* Mart.	Ingá	Amazônia, Caatinga, Cerrado, Atlantic Rainforest	SE; N; S (SC, PR); NE (BA, PE, RN)
Fabaceae (Mimosoideae)	*Inga vera* Willd.	Ingá	Amazônia, Cerrado, Atlantic Rainforest, Pampa, Pantanal	BR
Fabaceae (Papilionoideae)	*Andira fraxinifolia* Benth.	Angelim-roxo	Caatinga, Cerrado Atlantic Rainforest	SE (MG, SP); CW (GO, MS); S
Fabaceae (Papilionoideae)	*Pterocarpus violaceus* Vogel	Aldrago	Amazônia, Cerrado, Atlantic Rainforest	BR

Abreviattions: S=South; N=North; SE=Southeast; NE=Northeast; CW=Center-West; AC=Acre; BA=Bahia; BR=Brazil; CE =Ceará; GO=Goiás; MA=Maranhão; MT=Mato Grosso; MS=Mato Grosso do Sul; MG=Minas Gerais; PE=Pernambuco; PR=Paraná; RO=Rondônia; RJ=Rio de Janeiro; RN=Rio Grande do Norte; SC=Santa Catarina; SP=São Paulo; TO=Tocantins

Species were selected considering several characteristics such as occurrence, canopy, higher, growth rate and flowering. The higher should be medium-sized (around 20-meters, maximum) and preferably should present a moderate to fast growth rate (Table 2).

The species were also selected considering their ornamental qualities, based on color and flowering season. Color was diversified and staged to avoid uniformity and providing different blooming seasons (Table 2). Flower color and season were other factors aiming to have at least one species blooming in a given period. Also, species of the same flower color were avoiding to be planted in sequence.

The sequence of tree plantation was: North Avenue: 1) *Inga vera* and *Inga edulis;* 2) *Pterocarpus violaceus;* 3) *Cordia superba;* 4) *Jacaranda cuspidifolia:* 5) *Peltophorum dubium;* 6) *Senna multijuga. Goiabas Avenue:* 1) *Handroanthus impetiginosus;* 2) *Stifftia chrysantha* (Figure 2).

Table 2. Selected native species and phenological characteristics

Scientific name	Height (m)	Growth rate	Flower color	Blooming season	Nº of individuals
Senna macranthera	6-8	Fast	Yellow	Nov - Apr	33
Andira fraxinifolia	6-12	Slow	Pink	Nov - Dec	40
Pterocarpus violaceus	8-14	Moderate	Yellow	Oct - Dec	33
Cordia superba	7-10	Moderate	White	Oct - Feb	35
Jacaranda cuspidifolia	5-10	Fast	Yellow	Sep - Oct	31
Peltophorum dubium	15-20	Fast	Yellow	Dec - Feb	37
Inga vera	5-10	Fast	Cream	Aug - Nov	12
Inga edulis	15-20	Fast	Cream	Oct - Jan	19
Senna multijuga	6-10	Fast	Yellow	Dec - Apr	31
Handroanthus impetiginosus	6-10	Moderate	Pink	Sep - Oct	40
Stifftia chrysantha	3-5	Slow	Yellow	July - Sep	26

Source: Lorenzi, 2016.

Figure 2. Scheme of the species distribution along the avenues

Each species was planted on both sides of the avenue using an average spacing between the trees of 7.0 m. The first plantation was in year 2011 Summer (January). The plants had an average height of 1.60 m and were grown in 5-L plastic pots. For planting, a 40 x 40-cm hole was dug, and the soil was fertilized using 150 g of SSP - simple superphosphate and 20 L of cattle manure. For all the trees, a wood guide was provided. The irrigation was performed in manual way, three times a week. After one month, a few seedlings need to be replaced, using seedlings of the same age and size.

Three years after, *A. fraxinifolia* did not exhibit good development, characterized by death of the apical buds and over-sprouting at the base, and so it was replaced by another species, *H. impetiginosus*. Additionally, due to deficient development and constant stem crashes, *S. macranthera* was replaced by *P. violaceus*.

Assessments

Assessments of species development and behavior were performed initially – survival rate (%) and 7-years after the first planting, with the exception of *P. violaceus* and *H. impetiginosus*, which were evaluated at three and five years, respectively. The following parameters were evaluated: plant height (m), determined using a 17-m retractable metric tape, and canopy diameter (m), using measurements taken at two perpendicular positions in the canopy, using a metric tape. The diameter at breast height (DBH) (m) was calculated from the circumference at breast height (CBH) using a metric tape and according to the equation:

$$DBH = \frac{CBH}{\pi}$$

The RGR (TCR) = Relative Growth Rate was also determined to assess the increase in size per unit of measure and unit of time, allowing to minimize differences, through the equation (Mora et al., 2005):

$$TCR = \frac{Log_e S_2 - Log_e S_1}{t_2 - t_1}$$

Results and Discussion

The larger number of species selected in the family Fabaceae is explained by the fact that this is the most well-represented botanical family in Brazil (present in all states) (REFLORA, 2020). In Brazil, 222 genera and 2,848 species are described for the Fabaceae family (REFLORA, 2020). In addition, Fabaceae is one of the most diverse botanical families and the third largest in terms of number of species in the world (Gomes et al., 2018; LPWG et al., 2017)

In general, the seedlings had a survival rate around 100%, with the exception of *Cordia superba, Jacaranda cuspidifolia,* and *Senna multijuga,* which had survival rate around 80% and needed a replacement (Table 3).

Table 3. Performance of the native species after 7-years, in Lavras, Minas Gerais state, Brazil.

Species	Height (m)	RGR (m/m/ano)	Canopy diameter (m)	CBH	DBH	Survival rate (%)
*Handroanthus impetiginosus**	8.69	0.56	9.28	0.99	0.31	100
Inga edulis	6.70	0.20	9.1	0.53	0.16	100
Inga vera	5.02	0.16	5.9	0.36	0.11	100
Peltophorum dubium	10.21	0.26	9.87	0.70	0.22	100
*Pterocarpus violaceus***	4.84	0.22	3.52	0.25	0.08	100
Cordia superba	3.41	0.10	3.60	0.39	0.12	80
Jacaranda cuspidifolia	8.01	0.23	6.47	0.57	0.18	81.6
Senna multijuga	5.00	0.16	5.12	0.46	0.15	83
Stifftia chrysantha	3.72	0.12	3.63	-	-	100

*Five years after planting, **Three years after planting, CBH = circumference at breast height, DBH = diameter at breast height, RGR = Relative growth rate.

Through the RGR, it is possible to identify the growth rate of the species. It is observed that *Handroanthus impetiginosus* has the highest annual growth, as opposed to *Cordia superba* and *Stifftia chrysantha,* which have the lowest annual ratio.

Four weeks after planting, *A. fraxinifolia* had bacterial blight; thus, all the seedlings initially planted were replaced. Some plants of other species that were not successfully established in the soil were also replaced. Although the replanting of the *A. fraxinifolia*, the new plants present another time the same bacterial blight problem, which induced over-sprouting at the base, and the trees have lost quality characteristics for afforestation purposes.

A. fraxinifolia occurs in riparian or gallery forests, semideciduous seasonal forests, rain forests and restinga (REFLORA, 2020), which may indicate that this species requires very moist soils and must be cultivated in groups that allow the seedlings to protect one another (Silva et al., 2016). As a result of this non-adaptation, this species was fully replaced in 2013 by other species, *Handroanthus impetiginosus*.

Since the public pathways used for trees plantation was along a recently developed campus area, with no buildings, it was unprotected from wind. This situation affected the development of some species such as *S. macranthera*, which often toppled or had the stems crashed. Due to that, four years after, in 2015, this species was replaced by other that seems to be more resistant, *P. violaceus.*

Due to the negative experience of planting *S. macranthera* and *A. fraxinifolia*, these species cannot be recommended for public road afforestation in new developments or in areas without wind protection.

In general, establishment was satisfactory, and some replacements were only necessary for *S. macranthera* and *A. fraxinifolia.*

Considering the species evaluated 7-years after planting, *P. dubium* and *J. cuspidifolia* had the best performance. These species exhibited rapid development and over the evaluation period exhibited the best average plant heights (10.21 m and 8.01 m, respectively) (Table 3).

The canopy diameter of *P. dubium* and *J. cuspidifolia* was with an average size of 9.87 m and 6.4 m, respectively (Table 3). *P. dubium* may develop an even greater trunk diameter and canopy branching, occurring mainly in wet areas or in forests next to rivers or cricks (Bertolini et al., 2015). This species is also exceptional given its beautiful yellow-gold flowers that contribute to embellishment gardens and landscapes.

The rapid growth in height and good canopy development of *P. dubium* and *J. cuspidifolia* imply these species are an excellent option for urban afforestation (Figure 3).

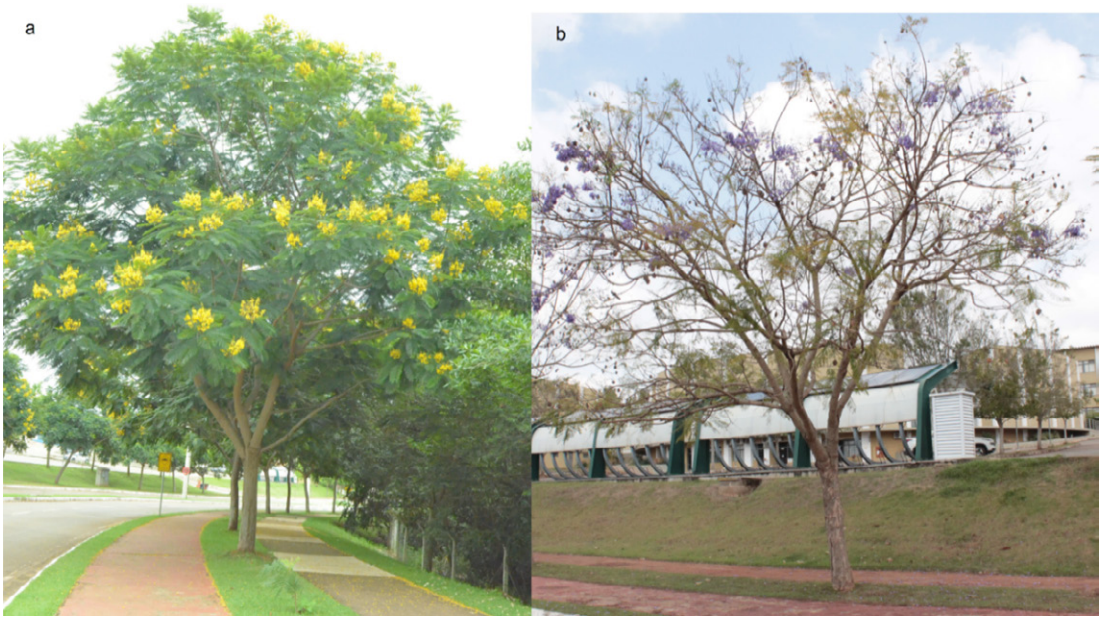

Figure 3. *Peltophorum dubium* (a) and *Jacaranda cuspidifolia* (b) trees 7-years old.

J. cuspidifolia is described as a deciduous, heliophilous and xerophilous species typical of the rocky slopes of broadleaf forests and of the transitional cerrado (Lorenzi, 2016). The leaves usually fall in driest months and after that, starting in September, produces purple flowers, providing a wonderful aspect for the tree. Other species of the genus Jacaranda, such as *J. cuspidifolia* and *J. chelonia*, are currently used for urban afforestation (urban forests, parks) and it has been noted an improving on microclimates (Labaki and Matzarakis, 2015; Soares et al., 2011) as well as the value of some of these tree services in different municipalities. This study describes one of the first applications of STRATUM outside the U.S. Lisbon's street trees are dominated by *Celtis australis* L., *Tilia* spp., and *Jacaranda cuspidifolia* D. Don, which together account for 40% of the 41,247 trees. These trees provide services valued at $8.4 million annually, while $1.9 million is spent in their maintenance. For every $1 invested in tree management, residents receive $4.48 in benefits. The value of energy savings is $6.20/tree. However, this is the first report of the use of *J. cuspidifolia* for pathway afforestation.

Another species that also exhibited good development was *H. impetiginosus*. This species presents by 100% establishment, an average height of 8.69 m and a canopy diameter of 9.28 m five years of planting (Table 3). The average DBH was 32 cm, and stem crash was not observed (Figure 4).

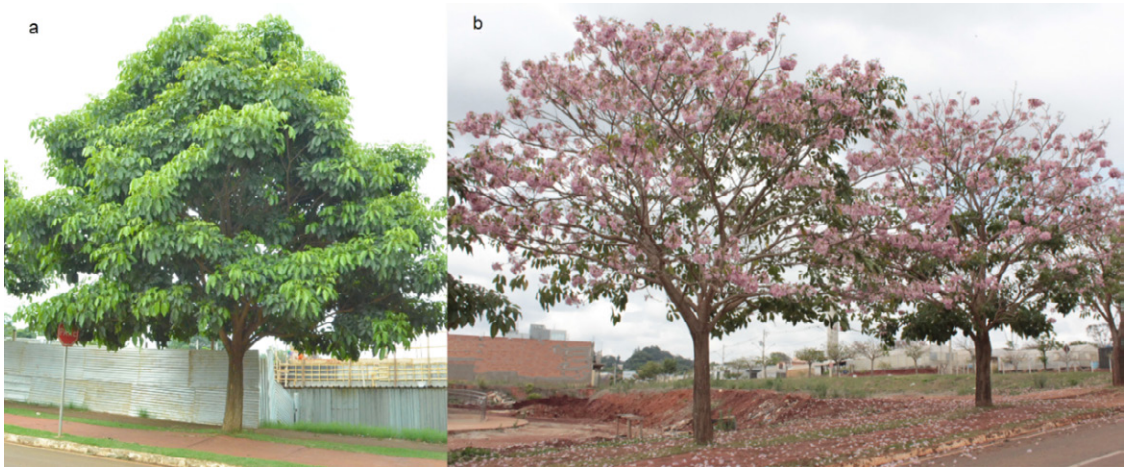

Figure 4. *Handroanthus impetiginosus,* 5-years old, characterized by a well-formed canopy (a) and a massive flowering during its blooming period (b).

H. impetiginosus has excellent ornamental features due to its attractive flowers. It is deciduous during the winter and the flowers appear just after, from May through August, in purplish-pink shades, offering an extremely beautiful scenic view (Lorenzi, 2016). Another interesting feature is that its dense canopy provides in other periods of the year an excellent shading.

The species with medium-sized higher include *S. multijuga* (Fig. 5) and the two *Inga* species *I. edulis* and *I. vera* (Fig. 6), which featured 83% and 100% establishment, respectively, in addition to present a fast development. The average height of *S. multijuga* was 5 m, with a canopy diameter of 5.12 m and a trunk diameter of 0.15 m over a period of 7-years (Table 3). *S. multijuga*, popularly known in Brazil as pau-cigarra, aleluia, cássia-aleluia, cássia-amarela, caobi, manduira, pau-amendoim, pau-de-pito and canudeiro, among other names, occurs largely in the country and is therefore adapted to different climatic conditions (Lorenzi, 2016). The size and shape of the canopy makes it suitable for the afforestation of pathway in narrow streets, mainly under electrical wiring, and it is widely used in street, park and garden afforestation in southeast Brazil (Lorenzi, 2016).

However, in this study, the species had not yet reached the average value of an adult tree (Figure 5). Some trees exhibited some dry branches, but no pests or diseases were observed.

Figure 5. *Senna multijuga,* 7-years old.

Inga edulis, commonly known in Brazil as ingá-cipó or ingá-de-macaco, has white and fragrant flowers, with long pod fruits that vary in size (Lorenzi, 2016). The fruit of this species is larger than those from *I. vera*, commonly known as ingá-do-brejo or ingá-babana, but both fruits are edible by animals and humans. There are no reports of the presence or use of these species in urban afforestation, but good canopy formation was observed, especially for *I. edulis*.

Although initially selected and thought to be a single species, after a few years it was confirmed that *I. edulis* planted in the area actually also included a second *Inga* species, I. *vera*. Due to that, a comparison between of the two *Inga* species, was performed and *I. edulis* (Figure 6a) presented better performance than *I. vera* (Figure 6b) in regard to the higher (6.7 m compared to 5.02 m) and canopy diameter (9.1 m compared to 5.9 m) (Table 3). Also, in visual observations, *I. edulis* blooms more frequently.

Figure 6. *Inga edulis* (a) and *Inga vera* (b), 7-years old.

The species that exhibited smaller sizes after 7-years were *C. superba* and *S. chrysantha* presenting an average height of 3.4 m and 3.7 m, and canopy diameter of 3.6 m, and 3.6 m, respectively (Table 3). *C. superba* occurs naturally in the southeastern states of Brazil. It is typically associated with wet soils, such as riparian forests and understory areas, and does not tolerate dry and acidic soils. It has great ornamental potential due to its white flowers. It has a large canopy what requires care when planted in narrow places or close to electrical wires (Lorenzi, 2016). Both species, *C. superba* and *S. chrysantha,* showed a slow-to-moderate growth (Figure 7).

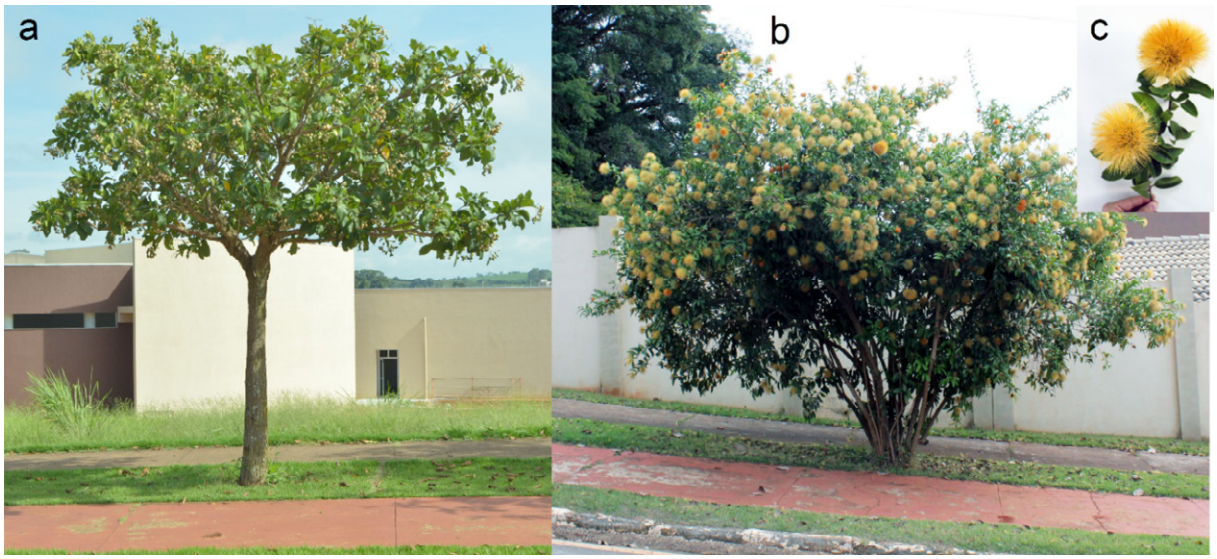

Figure 7. *Cordia superba* (a) and *Stifftia chrysantha* shrub (b) with inflorescence detail (c).

S. chrysantha had a 100% of establishment indicating excellent adaptability and resistance. It is important to highlight that *S. chrysantha* is a shrubby-like tree (or *arvoreta*), that explains the smaller size, but that has interesting features for use in sidewalks, even though it is not a tree. But as a shrub, the species exhibited multiple trunks (Figure 7), which provided a very interesting visual appearance.

Another evaluated species, *P. violaceus* exhibited good performance and establishment 3-years after planting (Figure 8), with an average height of 4.84 m and canopy diameter of 0.07 m (Table 3).

Figure 8. *Pterocarpus violaceus* three years after planting.

The species *P. violaceus* is a tree with attractive ornamental characteristics and is currently used in the state of São Paulo for both landscaping and urban tree-planting (Lorenzi, 2016). The species multiplies easily and tolerates direct solar radiation (Farrapo and Mendes, 2014). Moreover, *P. violaceus* decreases asphalt and sidewalk temperatures by 5 ± 2-3 °C, compared to similar sites without shade (Basso and Corrêa, 2014).

Based on the observations of this study, the species are differentiated, as is natural for plants. Thus, a simple indication of using native species in afforestation is not sufficient for a recommendation. Even being an occurrence occurring in a phytogeographic region, the species cannot adapt to a growing condition on pathways. Thus, through this study, it is possible to indicate species with potential for use in urban afforestation, such as *Handroanthus impetiginosus, Peltophorum dubium, Jacaranda cuspidifolia, Inga vera, Inga edulis, Pterocarpus violaceus* and *C. superba*. It is also important to note some do not showed adaptation, such as *Senna macranthera* and *Andira fraxinifolia* and may not be recommended for this purpose.

Conclusions

Native trees can be used for urban pathway afforestation, although not all species are adapted for this purpose. The medium-to-large size species *Handroanthus impetiginosus* and *Peltophorum dubium*, exhibited better performance and potential for urban afforestation, with good ornamental potential. Excellent characteristics were also observed for *Jacaranda cuspidifolia, Inga* vera, and *Inga edulis*. *Pterocarpus violaceus* presenting rapid development. Moreover, although it does not provide great shade, the *Stifftia chrysantha* shrub may be used in central beds or planted as hedges in isolation or in groups.

Author contribution

PDOP: project idea, implantation and conduction of the experiment, writing original draft and review. **MVR:** data collect, writing original draft and review**. RBS:** formal analyses, data collection and graphics elaboration. **RMF and MCRS:** data collect and formal analyses.

Acknowledgements

The authors are thankful to the Coordinating Agency for the Improvement of Graduate Education (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES); the Minas Gerais Research Support Foundation (Fundação de Amparo à Pesquisa do Estado de Minas Gerais – FAPEMIG) and the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq), for the scholarships and grant.

References

ALMAS, A.D.; CONWAY,T.M. The role of native species in urban forest planning and practice: a case study of Carolinian Canada. **Urban Forestry & Urban Greening,** v.17, p.54-62, 2016. https://doi.org/10.1016/j.ufug.2016.01.015

BASSO, J.M.; CORRÊA, R. Arborização urbana e qualificação da paisagem. **Paisagem e Ambiente: Ensaios**, v.34, p.129-148, 2014.

BEROLINI, I.C.; DEBASTIANI, A.B.; BRUN, R.J. Caracterização silvicultural da canafístula (*Peltophorum dubium* (Spregel) Taubert*)*. **Scientia Agraria Paranaensis**, v.134, n.2, p.67-76, 2015.

BIONDI, D.; LEAL, L. Avaliação de espécies plantadas experimentalmente na arborização de ruas da cidade de Curitiba–PR. **REVSBAU**, v.4; n.4, p.79-99, 2009. http://dx.doi.org/10.5380/revsbau.v4i4.66450

BIONDI, D.; LEAL, L. Monitoramento de mudas de *Allophylus edulis* (A. St.-Hil., Cambess. & A. Juss.) Radlk. plantadas experimentalmente na arborização de ruas da cidade de Curitiba-PR. **REVSBAU**, v.5; n.2, p.158-173, 2010. http://dx.doi.org/10.5380/revsbau.v5i2.66276

BOLDRIN, K.V.F.; NASCIMENTO, A.M.P.; PAIVA, P.D.O. **Árvores** - campus UFLA. Lavras: Editora UFLA, 2019.

CARVALHO, L.M.T.; SCOLFORO, J.R. **Inventário florestal de Minas Gerais**: monitoramento da flora nativa: 2005-2007. Lavras: UFLA, 2008. 357p.

CASTRO, A.S.F.; MORO, M.F.; ROCHA, F.C.L. Plantas dos espaços livres da Reitoria da Universidade de Fortaleza (UNIFOR), Ceará, Brasil. **Revista Brasileira de Biociências**, v.9, p.126-129, 2011.

COSTA, L.B.S.; PIRES, C.S.; ANJOS, J.S.; CORREIA, B.E.F.; ALMEIDA JÚNIOR, E.B. Floristic survey of ornamental plants used in Dom Delgado University City at the Universidade Federal do Maranhão, São Luís, Maranhão State, Brazil. **Ornamental Horticulture**, v.23, n.4, p.451-459, 2017. https://doi.org/10.14295/oh.v23i4.1129

CUPERTINO, M.A.; EISENLORHR, P.V. A comparative floristic analysis of the urban arborization in University campi in Brazil. **Bioscience Journal,** v.29, p.739-750, 2013.

MORA, F.; DEITOS, A.; ARNHOLD, E.; DANDOLINI, T.S. Análise do crescimento de árvores de sete anos de idade, originadas de estacas e sementes de *Pinus radiata* D. Don, provenientes de geração avançada de melhoramento. **Revista do Instituto Florestal**, v.17, n.2, p.207-213, 2005.

FARRAPO, C.L.; MENDES, R.F. Utilization of *Pterocarpus violaceus* wood in the particleboard production. **Scientia Florestalis,** v.42, p.329-335, 2014.

FERNANDES, C.J.; FERRAZ, M.V.; GIMENEZ, R.; PEREIRA, S.T.S.; PIVETTA, K.F.L. Trees description in the main square of São José do Rio Preto, São Paulo State, Brazil. **Ornamental Horticulture,** v.24, p.334-340, 2018.

FREIRE, M.G.M.; MUSSI-DIAS, V. Ornamental use of plants from the Restinga. **Ornamental Horticulture,** v.25, n.1, p.55-64, 2019. https://doi.org/10.14295/oh.v25i1.1452

GOMES, G.; SILVA, G.S.; SILVA, D.L.S.; OLIVEIRA, R.R.; CONCEIÇÃO, G.M. Botanical composition of Fabaceae family in the Brazilian Northeast, Maranhão, Brazil. **Asian Journal of Environment & Ecology**, v.6, p.1-10, 2018.

GUILHERME, F.A.G.; SILVA, M.C.; CARNEIRO, D.N.M.; NASCIMENTO, H.C.A.; RESSEL, K.; FERREIRA, W.C. Urban arborization in public pathways of four cities in East Mato Grosso do Sul (MS) Brazil. **Ornamental Horticulturae,** v.24, p.174-181, 2018.

LI, X.; RATTI, C.; SEIFERLING, I. Quantifying the shade provision of street trees in urban landscape: a case study in Boston, USA, using Google Street View. **Landscape and Urban Planning**, v.169, p.81-91, 2018.

LIMA NETO, E.M.; BIONDI, D.; PINHEIRO, F.A.P.; CONDÈ, T.M.; DIAS, L.; GONÇALVES, M.P.M. índices ecológicos para a gestão da arborização de ruas de Boa Vista-RR. **REVSBAU**, v.16, n.1, p.21-34, 2021.

LORENZI, H. **Árvores brasileiras**: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. v.1, 2 e 3. Nova Odessa: Instituto Plantarum, 2016.

LPWG -The Legume Phylogeny Working Group. A new subfamily classification of the Leguminosae based on a taxonomically comprehensive phylogeny. **Taxon**, v.66, p.44-77, 2017.

MELLO, S.S.; PASTORE, J.B. Flora ornamental do Cerrado no paisagismo: retrato da aplicação prática. **Ornamental Horticulture**, v.27, n.1, p.78-87, 2020. https://doi.org/10.1590/2447-536X.v27i1.2254

OLIVEIRA, A.F.; NEVES, C.L.; PEREIRA, G.A.; GARCIA, F.H.S.; COELHO, S.J.; PEREIRA, J.A.A. Floristics of road forestry conflicting with the electrical networks: a case study in the southern region of Minas Gerais State. **Ornamental Horticulture**, v.24, n.3, p.277-284, 2018. https://doi.org/10.14295/oh.v24i3.1239.

PAIVA, P.D.O.; LANDGRAF, P.R.C.; RODRIGUES, T.M.; PEDROSO, D.O.; FILHO, T.O.; GAVILANES, M.L.; PAIVA, R. Identification and characterization of the trees species of the central garden of the Universidade Federal of Lavras/MG. **Ciência e Agrotecnologia**, v.28, n.3, p.515-519, 2004.

PEREIRA, J.V.R.; GIRARDI, L.C.; MENEGAES, J.F.; FERREIRA, I.G.P.; MONTEIRO, D.M. survey of the median strip afforestation of Brasil avenue (neighborhood center) in the municipality of Passo Fundo, RS. **REVSBAU**, v.15, n.4, p. 62-72, 2020.

RAHMAN, M.A.; MOSER, A.; RÖTZER, T.; PAULEIT, S. Microclimatic differences and their influence on transpirational cooling of *Tilia cordata* in two contrasting street canyons in Munich, Germany. **Agricultural and Forest Meteorology**, v.232, p.443-156, 2017.

SILVA, K.R.; JUNIOR, J.C.F.M.; BOEGER, M.R.T. Variações fenotípicas em *Andira fraxinifolia* Benth. (Fabaceae) em duas fitofisionomias de restinga. **Hoehnea**, v.43, n.2, p.237-145, 2016

STUMPF, E.; SILVA, P.; ROMAGNOLI, I.; FISCHER, S.; MARIOT, M. Espécies nativas que podem substituir as exóticas no paisagismo. **Ornamental Horticulture**, v.21, n.2, p.165-172, 2015. https://doi.org/10.14295/aohl.v21i2.663

REFLORA. **Fabaceae in flora do Brasil** - Jardim Botânico do Rio de Janeiro. Available at: http://www.reflora.jbrj.gov.br/reflora/floradobrasil/FB115. Accessed on: October 22, 2018.

REVELLI, R.; PORPORATO, A. Ecohydrological model for the quantification of ecosystem services provided by urban street trees. **Urban Ecosystems**, v.21, p.489-504, 2018.

SAITER, F.Z.; EISENLOHR, P.V.; FRANÇA, G.S.; SETEHMANN, J.R.; THOMAS, W.W.; FILHO, A.T.O. Floristic units and their predictors unveiled in part of the Atlantic Forest hotspot: implications for conservation planning. **Anais da Academia Brasileira de Ciencias**, v.87, n.4, p.2031-2046, 2015.

SICARD, P.; AGATHOKLEOUS, E.; ARAMINIENE, V.; CARRARI, E.; HOSHIKA, Y.; MARCO, A.; PAOLETTI, E. Should we see urban trees as effective solutions to reduce increasing ozone levels in cities? **Environmental Pollution**, v.243, p.163-176, 2018.

SOARES, A.L.; REGO, F.C.; MCPHERSON, E.G.; SIMPSON, J.R.; PEPER, P.J.; XIAO, Q. Benefits and costs of street trees in Lisbon, Portugal. **Urban Forestry & Urban Greening**, v.10, n.2, p.69-78, 2011.

SOLTANI, A.; SHARIFI, E. Daily variation of urban heat island effect and its correlations to urban greenery: a case study of Adelaide. **Frontiers of Architectural Research**, v.6, p.529-538, 2017.