Studies on *Spiraea x vanhouttei* Growth Under the Influence of Sun Exposure

Raluca TOMA^{1*)}, Dumitru ZAHARIA²⁾

¹⁾ Faculty of Horticulture, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Calea Mănăştur 3-5, 400372, Cluj-Napoca, Romania

^{*)} Corresponding author, e-mail: ralucatoma17@yahoo.com

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Abstract

The purpose of this study is to show the influence of built environment over plant development in urban areas. It is well known that environmental factors are influenced by the built environment and human activities within the cities. Built environment affects especially the temperature of ambient due to the interaction between solar radiations, the materials from which buildings and streets are made of, as well as the urban design. Direct sun exposure and its direct effects are most affected by urban tissue configuration within the area. Observations were made over phenological evolution of *Spiraea x vanhouttei* species during four years, in Cluj-Napoca, Romania. The study area was selected because the environmental conditions (precipitations, wind, pollution etc.) that can affect the development of hedges are identical, except for sun exposure. The shading period, established with the sun-study tool of ArchiCAD, to which the plants were exposed, differ on the north and south part of the study area respectively, and thus generated differences regarding the phenological stages of leaf development and flowering.

Keywords: *sun exposure, solar radiation, phenological stages, urban environment.*

INTRODUCTION

Phenology is a discipline that observes and studies the evolution of plant development and animal activities which have a cyclic character and coincide with the seasonal development generated by the sun annual cycle, especially in temperate climates (Schwartz, 2003). The connection between sun and vegetation is undeniable. Plant phenology, especially during spring season, is affected by temperature and photoperiod (Beverly, 2007; Polgar and Primack, 2011).

Researchers lately noted that there are differences in plant phenology in urban areas as compared to rural areas (Roetzer *et al.*, 2000; Kaesha and Jianguo Wu, 2006). Those differences are noticeable in the tendency to leaf out and blossom earlier in urban areas. This phenomenon is due to the fact that the urban environment has distinct characteristics as compared to rural surroundings, which are closer to the natural landscape, opposite to the built environment's that influence the urban climate. The materials

and shape of buildings and of urban surfaces, as well as urban design (form, height and placement) impinge on the urban microclimate especially over the hygrothermal aspects (Dessi, 2010).

Urban microclimate is influenced by solar radiation, but also by terrestrial radiation. Solar radiation that reaches the earth is mostly within the visible spectrum and has two components: direct solar radiation and diffuse sky radiation. Direct solar radiation is the one that has an important impact over the energy balance of an area, especially on a sunny day. On the other hand, terrestrial radiation is the one which is reflected by, or absorbed and later reemitted, by the objects and surfaces of the urban environment. Terrestrial radiation is in the infrared spectrum and affects the microclimate (Scudo and Ochoa de la Torre, 2006).

The type of materials used for buildings influences the energy balance through features such as albedo, emissivity, specific heat and thermal diffusivity. These features are specific

for each material and are influenced by direct sun exposure, which affects the amount of heat accumulated by surrounding objects, and thus thermal radiation in the area, which in turn influences the ambient temperature (Dessi, 2010).

The objective of this study is to show the influence of built environment over plant phenology. It aims to emphasise the importance of the urban microclimate over the ornamental vegetation phenology.

MATERIALS AND METHODS

Observations were conducted over a period of four years between 2011 and 2014, in Cluj-Napoca. During this interval, emphasis was made on the phenological development in springtime of *Spiraea x vanhouttei* hedges located along Donath Street. This location was chosen because of hedge vegetation that was exposed to the same environmental conditions (pollution, wind, precipitation, etc.) except the periods of direct sun exposure, which differs along the two sides of Donath Street. The differences of direct sun exposure are due to the west – east street axis orientation and the buildings' height (over 14 m), arranged along both sides of the street.

Because leaf out and flowering are two phenological stages sensitive to environmental conditions like temperature, photoperiod and light intensity, conditions that are directly connected to solar radiation, their development has been monitored.

The BBCH (**B**iologische **B**undesanstalt, **B**undessortenamt and **C**hemical industry) code was

used to establish the phenological stages (Hack *et al.*, 2001; Finn *et al.*, 2007). Phenological stages were considered as followed: stage 11 is the leaf out moment when the first leaves begin to unfold, stage 61 – is the beginning of flowering and represents the moment when 10% of the flowers open and stage 69 - end of flowering represents the moment when all flowers have fallen or faded out.

Daytime duration (number of hours from sunrise to sunset) for Cluj-Napoca was calculated using the online calculator of "Amiral Vasile Urseanu" Astronomical Observatory in București (Tab. 1)

ArchiCAD was used to determine sunlight exposure of the studied area. Aided by the applications of this program, the built environment was virtually constructed and later used for a sun study calculation. The sun study was made for the period between March the 1st and June the 1st which corresponds to the period from leaf out to flowering of *Spiraea x vanhouttei* species. The geographical coordinates of Cluj-Napoca were introduced in the program database: 46°46' North, 23°36' East, respectively +2 h GMT. The program generated realistic building shadows during daytime and thus allowed to establish the number of hours of direct sunlight exposure and those of shade (Fig. 1).

The obtained results were correlated with the starting dates of the three phenological stages that were established before.

Tab. 1. Length of day light during the spring season in Cluj-Napoca

	Date													
	1.03	7.03	14.03	21.03	28.03	4.04	11.04	18.04	25.04	2.05	9.05	16.05	23.05	30.05
Sun rising	7:06	6:55	6:41	6:27	6:13	7:00 DST	6:46 DST	6:33 DST	6:21 DST	6:09 DST	5:59 DST	5:50 DST	5:43 DST	5:37 DST
Sunset	18:11	18:20	18:30	18:39	18:49	19:59 DST	20:08 DST	20:18 DST	20:27 DST	20:37 DST	20:46 DST	20:55 DST	21:03 DST	21:10 DST
Daylight Hours	11h 5'	11h 25'	11h 51'	12h 12'	12h 36'	12h 59'	13h 32'	13h 46'	14h 6'	14h 28'	14h 47'	15h 5'	15h 20'	15h 33'

NOTE: DST (Daylight Saving Time) represents the summer time included in the calculations

Fig. 1. Sun study excerpt on Donath Street

Tab. 2. Length of sun exposure on both sides of Donath Street

Date														
1.03	7.03	14.03	21.03	28.03	4.04	11.04	18.04	25.04	2.05	9.05	16.05	23.05	30.05	06.06
Length of sun exposure on the north side of Donath Street														
6h 30'	7h 15'	7h 45'	8h 20'	9h	10h 30'	10h 50'	11h 12'	11h 15'	10h 50'	10h 40'	10h 30'	10h 20'	10h 15'	10h 10'
Length of sun exposure on the south side of Donath Street														
1h 11'	1h 50'	2h	2h 10'	2h	2h 15'	2h 35'	2h 45'	2h 50'	3h 10'	3h 20'	3h 20'	3h 30'	2h 45'	2h 45'

RESULTS AND DISCUSSION

The sun study showed that plants on the south side are exposed less than 3.5 hours to direct sunlight, whereas plants situated on the north side were exposed to sunlight for at least 6 hours a day in March, and as much as 11 hours a day in the second half of April (Tab. 2).

The starting point of leaf out and the beginning of flowering and its duration were determined during four seasons. Calendar days were used to assess the starting point of each phenological stage. DOY (Day Of Year) was used to assess the duration of phenological stages (Tab. 3).

Analysing data of the beginning of phenological stages during the four year period shows that are significant differences between the two sides of the street.

Leaf out starting point – stage 11 – was happening later on the south side of the street. The average difference between the times until leaf unfolding was by 7 day earlier on the north side compared to the south side of the street.

The beginning of flowering – stage 61 – took place later on the south side of the street, on average by 5.5 days from the onset on the north side.

Tab. 3. Beginning and length of phenological phases in Donath Street for *Spiraea x vanhouttei*

Year	Donath street side	Beginning of leaf development	Time until leaf unfolding	Beginning of flowering	Time until flowering	Ending of flowering	Time until ending of flowering	Flowering length
		BBCH 11		BBCH 61		BBCH 69		
		calendar day	DOY	calendar day	DOY	calendar day	DOY	days
2011	North	30.03	89	12.05	132	23.05	143	11
	South	06.04	96	18.05	138	02.06	153	15
2012	North	31.03	91	06.05	127	18.05	139	12
	South	07.04	98	10.05	131	26.05	147	16
2013	North	02.04	92	02.05	122	16.05	136	14
	South	08.04	99	09.05	129	27.05	147	18
2014	North	12.03	71	27.04	117	17.05	137	20
	South	19.03	78	02.05	122	26.05	146	24

Fig. 2. Images of the hedges on Donath Street, the north side on the left and the south side on the right on April 3rd, 2011 **Fig. 3.** Images of the hedges on Donath Street, the south side on the left and the north side on the right on May 10th, 2012

Also the end of flowering – stage 69 – occurs on average 9.5 days later on the south side of the street than on the north side.

The flowering period is longer on the south side of the street on average by 4 days than on the north side.

Differences of phenological evolution are visible both during leaf out and during flowering, but because the hedges are pruned each year to maintain the geometrical shape, the effect is more obvious during the leaf unfolding (Fig. 2) than during the blossoming (Fig. 3).

Over the years it became well known that urbanization has a very important impact on climate conditions and the urban heat island phenomenon is well known. Especially the thermal properties of building materials increase the quantity of solar radiation accumulated in the urban areas (Gartland, 2008). Numerous studies and research has been conducted to mitigate the urban microclimate conditions and vegetation is considered as a powerful instrument in the process (McPherson, 1992; Scudo and Ochoa de la Torre, 2006; Dessì, 2010). On the other hand studies on the impact of built environment over the urban vegetation, especially the ornamental shrubs haven't been found even though it is well known that temperature and light affect plant development (Zaharia *et al.*, 2008).

CONCLUSIONS

Sunlight affects phenological development of *Spiraea x vanhouttei* species. Plants that have been exposed for a longer time to direct sunlight begin to leaf out and to blossom earlier than those that are on direct sun light for a shorter period. Sun exposure affects also the duration of flowering and its end, as the flowering period is longer on south side.

The comprehension of the manner in which plants develop under the influence of shading can help landscape architects to choose adequate species to the given location during project elaboration. Designing hedges made with vegetation sensitive to sunlight exposure

along urban areas can generate discrepancies between side images, because of the differences that occur between phenological stages. Those dissimilarities, especially during spring time, offer completely different images than the intention of landscape architects, who might have imagined symmetry and uniformity as specific to a geometric organized space when using the same species on the hedges.

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