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The observation of frost resistance and growth rate of some chosen ground cover shrubs in street conditions in Warsaw

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Abstract: *The observation of frost resistance and growth rate of some chosen ground cover shrubs in street conditions in Warsaw.*The more cars there are in our streets the worse conditions for the street trees and shrubs are. That is why it is necessary to prepare the list of plants suitable for the most severe urban condition, which is based on field experiments. This paper shows the results of the experiment conducted on ten species and cultivars of ground cover plants grown along one of the main Warsaw street. The work was carried out in the years 2004–2005. According the results of the work the most suitable plants are *Spiraea japonica* 'Froebelli', *Rosa rugosa* and *Spiraea japonica* 'Goldmound' while *Cotoneaster dammeri* 'Eichholz', *Stephanandra incisa* 'Crispa' and *Spiraea japonica* 'Anthony Waterer' are unsuitable. The initial maintenance play crucial role in plants assimilation and further successful grow. The distance from the street kerbstone had the significant influence on all the tested features apart from high and diameter increase in the first year of testing.

Key words: ground cover shrubs, street shrubs, plant selection, landscape architecture.

INTRODUCTION

In the past few years more attention is paid to city greenery quality particularly in the most difficult conditions for dendrite plants that is along communicating main roads. Conditions there and their possible influence were not once labelled (Goździk and Piskornik, 1969a, b; Greszta et al., 2002; Borowski and Latocha, 2006). The authors give information about different kinds of contamination influence on the plants whereas there is a little information about plants tolerance to synergistic activity of these factors. Therefore it seems to be purposeful action to conduct studies with possible many kinds of species in the most difficult environmental conditions (Bugała et al., 1984; Łukasiewicz, 1995; Borowski and Latocha, 2006). The studies should also take into consideration the period of plants after planting because it is a crucial issue to its farther growth. Only such results seem to be more authoritative estimation of their immunity.

In present article results of studies conducted on ten species and cultivars of shrubs along one of the busiest streets in Warsaw were presented. The object of these studies was both their usefulness estimation and the influence on the studied parameters of their distance from the road.

CONDITIONS OF THE EXPERIMENT

The researches were conducted during two seasons; since spring 2004 till spring 2006. The area of the researches was directly in the neighbourhood of Al. Niepodległości

in Warsaw on the section between Rakowiecka and Dąbrowskiego Street. It is one of the busiest roads in Warsaw with two lanes in both directions and movement intensity up to 5.000 cars per hour (rush hours) and 75.000 cars per week.

The salinity level of the soil in the neighbourhood of Al. Niepodległości was high already in the 70's according to Czerwiński studies (1970). Current level of soil salinity can be estimated on the basis of intensity of salinity in winter. As we can see in City Cleaning Board (ZOM) data 2004/2005 season belonged to rich in snow however 2005/2006 was record-breaking in this respect (oral information). On average in winter season the street was strew with 900 g of NaCl on each square meter. Also typical syndromes occurring in research years on linden growing along the street bears the evidence about high level of soil salinity (leaf boundary necrobiosis and its premature falling).

Weather conditions in both seasons of research and minimum temperatures in Winter are presented on Figures 1, 2 and 3. The data comes from the com-

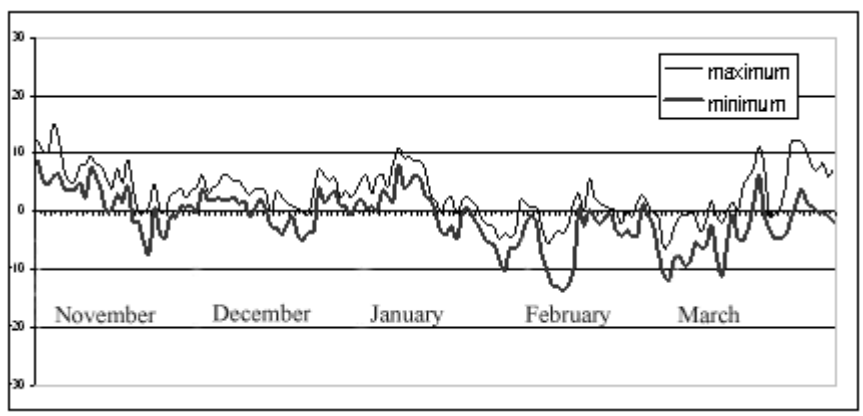

FIGURE. 1. Minimum and maximum temperature in the period November 2004 – March 2005

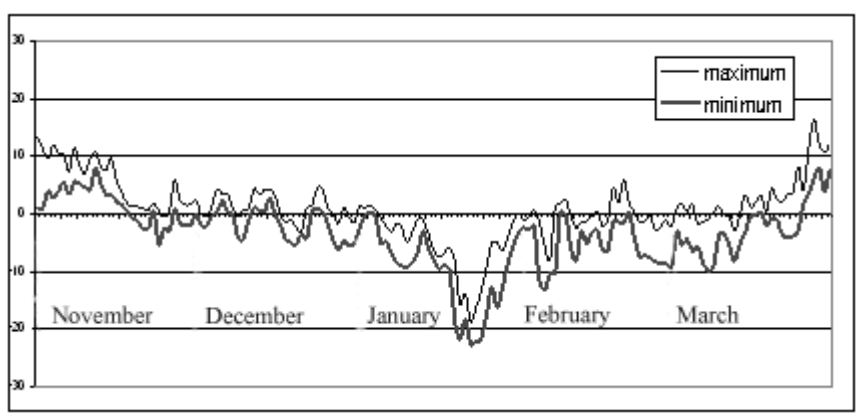

FIGURE. 2. Minimum and maximum temperature in the period November 2005 – March 2006

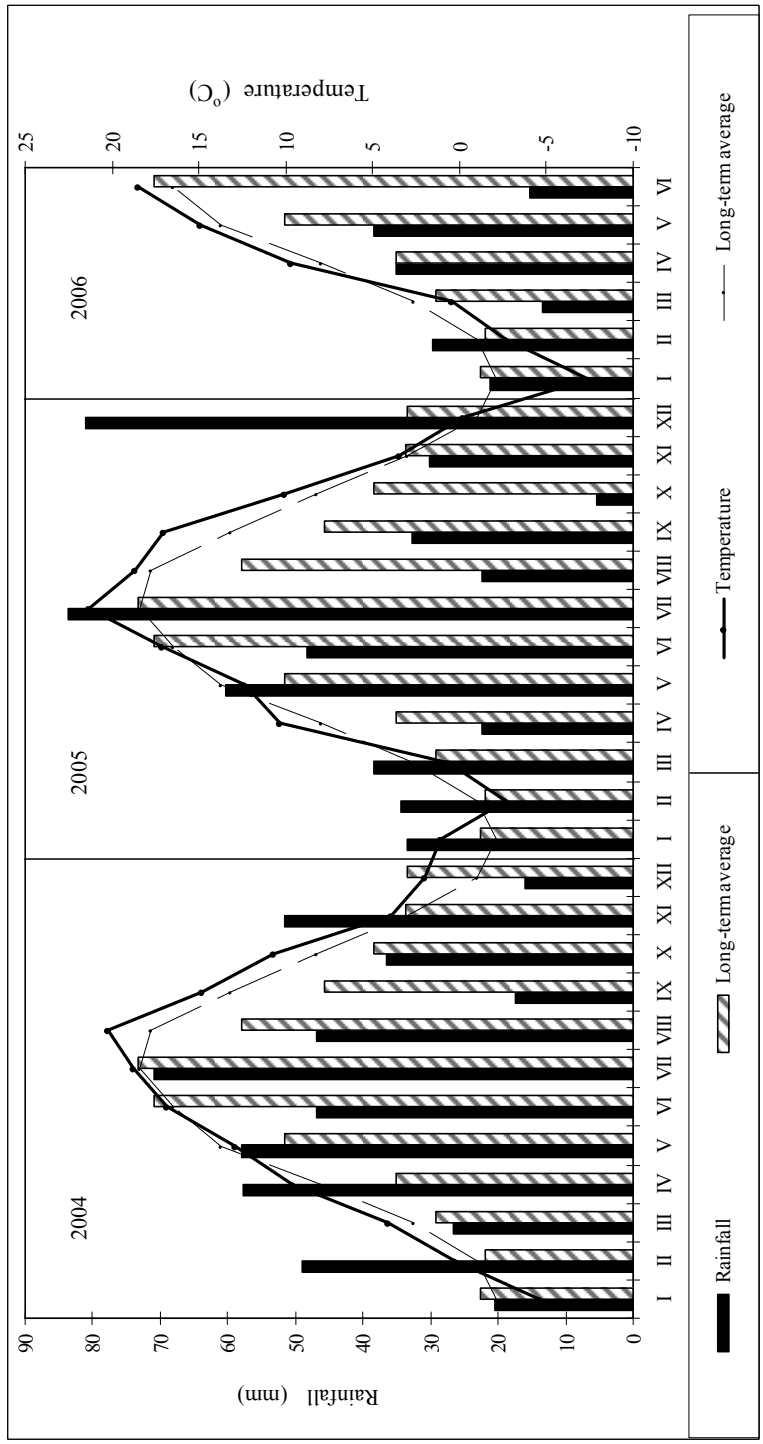

FIGURE. 3. Rainfall and temperature in the period of the experiment in the comparison to the average of 30 years

munication weather station located on Aleja Niepodległości about 1000 meters from the research area. (IOŚ 2005, IOŚ 2006).

In both years the average yearly temperature was higher than long-term average for abort 1°C. The higher summer temperatures had the biggest influence for it. However atmospheric precipitation in every season were similarly spread and did not exceeded 500 mm in total. Winter 2004/2005 was unusually variable definitely warmer that typical at the beginning December–January and in February–March cooler. Longer warmer periods were intertwined with cooler ones. The lowest temperature fell to –15°C. Whereas Winter 2005/2006 was long and belonged to the frostiest since last 20 years. The minimum temperature fell to 22.6°C. The cooler month was January with its average temperature lowest than standard for 5.3°C but also March had lower for 2.2°C temperature that multi-annual average. Furthermore record-breaking snowing was written down what resulted in more intensive works against glazed frost.

MATERIAL AND METHODS

The studies were conducted on ten species and cultivars of shrubs mostly considered to be ground cover shrubs (Tab. 1). The plants were set on spring 2004. To the research were selected plants located in the same distance from the street in two lanes: first in distant about 0, 5 m from the kerbstone and the second about 1.7 m from the kerbstone. The plants were set in holes laced with fertile soil. After planting they were profusely watered and the area around them was lined with 5 cm composted pine bark. The watering was repeated after two weeks. Farther catering was not done. The plantings were weeded as it was needed; after first winter the cultivation cutting consisting of removal of frozen parts was done. Fertilization was not conducted. Each of studied species or kind was represented by three similarly localized fields and each of them was treated as a repetition. On each field were at least 15 pieces of plants. The influence of the distance from the street on particularly estimated plants parameters was independently considered. Observation and measurement was

TABLE 1. Species and cultivars included in the study

Species, cultivar	High [cm]	Planting density [cm]
Berberis thunbergii 'Atropurpurea'	150–200	50×50
Cotoneaster dammeri 'Eichholz'	25	40×40
Cotoneaster horizontalis	60–100	100×100
Potentilla fruticosa 'Goldfinger'	130	50×50
Ribes alpinum 'Schmidt'	150	40×40
Rosa rugosa	150	50×50
Spiraea japonica 'Anthony Waterer'	70–80	50×50
Spiraea japonica 'Froebelli'	100	50×50
Spiraea japonica 'Goldmound'	50–60	50×50
Stephanandra incisa 'Crispa'	30–50	50×50

conducted individually on every plant and the field result was averaged. To estimate influence of the distance from the street to studied parameters results for plants growing nearer and farther from the street were separately averaged.

Biometrical parameters measurement (diameter and height) were conducted for two seasons, observation of plants survivability after each vegetation season and frost damages after winter and estimation of plants healthfulness was done.

The estimation of frost damages were conducted after each winter in the middle of May. To the estimation was used 11 degree scale of frost damages (0–10) commonly used in botanical garden and arboreta (Baran and Stuchlik, 1992) in which it was modified to be useful for estimation of grand cover shrubs (Latocha, 1999). Totally frozen plants are marked with 0.

The vegetables live ness, understood as a percentage of plants living at the end of each vegetate period versus planted vegetables was estimated in the end of October in each season of research.

The healthfulness of plants estimation was conducted in an aspect of its aesthetical value. It was done three times in a period (beginning of June, August and October) in accordance to established botanical scale allowing for disease paralysis degree, pests and other damages indication on leafs or sprouts (Tab. 2).

The measurement of height and width of plants were conducted at the beginning (May) and in the end (October) of each research season. The height was measured fivefold to each plant. The width twice or thrice (minimum and maximum width). Gained in his way results were averaged for the lane closer and farther from the street and for the whole field. The difference between fall and spring measurement consists of width and height gain. On the ground of width and height gain measurement the coverage of

TABLE 2. The estimation scale of plants healthfulness

Points of assessment scale	Health status description
0	All plants died away or are fading.
1	Mass occurrence of pests and diseases 80–100% of plants infected. Serious damages having influence on growth and aesthetic values of plants occurred (deformation, growth cohabitation). More than 70% of ill leafs (necrobiosis, chloranaemia). Premature leaf fall may occur.
3	61–80% of plants are paralysed with pests or diseases (clearly seen damages). 51–70% leaf with disease changes. Premature leaf fall may occur.
5	41–60% of plants paralysed with pests or diseases (not too strong damages). 26–50% leaf with disease changes. Only insensible premature leaf fall can occur.
7	21–40% of plants paralysed with pests or diseases but they behave normal shape and colour. Up to 25% of leafs can have necrobiosis or chloranaemia effects. Non significant aesthetical value decrease.
9	Up to 20% of plants paralysed with pests or diseases, almost without any influence on its aesthetical values decrease.

the area by particular species degree was enumerated by the following pattern:

$$W = T/S \cdot 100\%$$

where: T – stands for the surface with which the plant gains total coverage for used span, S – effective surface occupied by plants.

It was assumed that the full coverage is achieved when plants starts to connect with each other that means when every one reaches the half distance between them. The speed of area coverage is the difference between the last and first measurements in each season.

In order to reach the final estimation of studied species gained percentage results were recounted to points of assessment scale and summed up for every examined kind (Tab. 3).

TABLE 3. Converting percentage into the points of assessment scale

Points of assessment scale	Percentage
1	under 20%
3	21 to 40%
5	41 to 60%
7	61 to 80%
9	above 80%

The results of frost resistance estimation, liveliness, the growth of width and height and also the area coverage growth was exposed to one factor variance analysis separately for each season. LSD test was used for the evaluation of the significance of differences between the means accepting the significance level as 5%. For estimation of distance from the street influence on studied parameters double factor variance analysis was used and averages were compared with Newman-Keuls test at $p = 0.05$.

RESULTS AND DISCUSSION

The average results of all conducted measurements and observation are presented in Table 6. The best frost resistance after quite smooth winter 2004/2005 was shown by: *Spiraea japonica* 'Froebelli' (7.8 points), 'Goldmound' (7.2 points) and *Rosa rugosa* (6.5 points). However *Cotoneaster dammeri* 'Eichholz' (0.4 points), *Spiraea japonica* 'Anthony Waterer' (1.0 points) and *Stephanandra incisa* 'Crispa' (1.3 points) almost completely frozen. The second, more severe winter considerably damaged the majority of the remaining plantings. *Potentilla fruticosa* 'Goldfinger' (1.5 points) and *Cotoneaster horizontalis* (1.6 points) suffered most. The same kinds as in first winter survived the best – *Rosa rugosa* (4.8 points), *Spiraea japonica* 'Froebelli' (4.1 points) and 'Goldmound' (3.1 points). However even between them 25–50% of plants were totally frozen. The plants survivability test results after the first period of studies bear the evidence of a high level of rooted plants out of examined ones (more than 90%). Only *Cotoneaster dammeri* 'Eichholz', *Spiraea japonica* 'Anthony Waterer' and *Stephanandra incisa* 'Crispa' demonstrated low level of rooted plants (18.6%, 60.9% and 63% respectively) what was the result of low level of atmospheric precipitation in June 2004 and lack of sufficient maintenance. After the second year of research the highest survivability was shown by *Spiraea japonica* 'Froebelli', *Berberis thunbergii* 'Atropurpurea' and *Rosa rugosa*. It was the result of very severe winter 2005/2006. Those results showed the crucial role of plants maintenance in the first year for their farther growth. It is especially important for evergreen plants

which are more sensitive to drought and salinity stress. The highest growth of area coverage after two seasons was shown by *Spiraea japonica* 'Froebelli' (100%) and *Rosa rugosa* (58.4%) the lowest *Spiraea japonica* 'Anthony Waterer', *Cotoneaster dammeri* 'Eichholz' and *Stephanandra incisa* 'Crispa' which almost completely fell out. Results of plants healthfulness were similar. The species which demonstrated the best adaptation to research conditions also characterised with the best healthfulness. The highest grade was achieved by *Berberis thunbergii* 'Atropurpurea' (8.3 points), *Spiraea japonica* 'Froebelli' (8.0 points) and *Rosa rugosa* (6.8 points), while the worst one was graded to *Spiraea japonica* 'Anthony Waterer', *Cotoneaster dammeri* 'Eichholz' and *Stephanandra incisa* 'Crispa', which consecutively died away in the first year of studies. In the case of *Cotoneaster dammeri* it was apparently caused by its sensibility to salinity which was indicated in the Marosz works (2001).

The final classification of studied species and cultivars confirmed particular studied parameters results – after two year studies the *Spiraea japonica* 'Froebelli' (37.9 points), *Rosa rugosa* (32.8 points) and *Spiraea japonica* 'Goldmound' (30.3 points) gained the highest grades. The lowest estimation was given to *Cotoneaster dammeri* 'Eichholz' (4.1 points), *Stephanandra incisa* 'Crispa' (6.9 points) and *Spiraea japonica* 'Anthony Waterer' (7.2 points). As far as low estimation of first two genotypes do not surprise (the first one is evergreen and the second is very drought sensitive) but the poor estimation of one of the cultivars of Japan meadow-sweet is astonishing. All the more two other cultivars of this species were recognized as the one of the best during the experimental period. The final classification specification of all examined species and cultivars is presented in Table 4.

The results of studies over the influence of plants distance from the street

TABLE 4. Final classification of tested species and cultivars (points of assessment scale)

Species, cultivar	Frost resistance	Survival rate	Pace of ground covering	Health rate	Sum	Maximum
Spiraea japonica 'Froebelli'	11.9	9	9	8	37.9	47
Rosa rugosa	11.3	9	5.7	6.8	32.8	
Spiraea japonica 'Goldmound'	10.3	9	4.3	6.7	30.3	
Berberis thunbergii 'Atropurpurea'	7.7	9	1.7	8.3	26.7	
Ribes alpinum 'Schmidt'	6.7	7.7	5	5.3	24.7	
Potentilla fruticosa 'Goldfinger'	6.0	7	2.3	5.6	20.9	
Cotoneaster horizontalis	4.8	6.2	0	4.3	15.3	
Spiraea japonica 'Anthony Waterer'	1.0	3.2	0	3	7.2	
Stephanandra incisa 'Crispa'	1.3	3.3	0	2.3	6.9	
Cotoneaster dammeri 'Eichholz'	0.4	1.7	0	2	4.1	

TABLE 5. The influence of the distance from the track on the tested features

Features	Frost resistance		Survival rate		High increase		Diameter increase	
Years of the experiment	2004/5	2005/6	2004	2005	2004	2005	2004	2005
Statistical significance	**	*	*	*	n.s.	*	n.s.	*

n.s. – not significant , * $p \leq 0.05$, ** $p \leq 0.01$

show that it has its influence in different degree on particular examined elements (Tab. 5). In case of biometrical parameters differences in plants growth were observed only in the second year what seems to be reasonable because in the first year plants were just rooted. It is presented by the measurement of plants height and diameter results. However in case of frost resistance the influence of the distance was important in both years what is confirmed with unfavourable influence of streets on plants growing in the nearest neighbourhood. It can be assumed that plants after rooting in the first season, in the next years longer distance from the street have clearly profitable influence on plants evolution and frost resistance. Although dependence is stronger if winter is milder.

CONCLUSIONS

1. Received results showed that proper maintenance in the first two periods is crucial for root system development and further healthy growth.
2. Among investigated coverage plants species and cultivars with the highest resistance for street conditions or insufficient nurture were: *Spiraea japonica* 'Froebelli', *Rosa rugosa* and *Spiraea japonica* 'Goldmound', which received the highest grades.
3. Particularly sensitive to insufficient nurture after planting turned out as follows: *Cotoneaster dammeri* 'Eichholz', *Stephanandra incisa* 'Crispa' and *Spiraea japonica* 'Anthony Waterer', characterised with low level of taking roots and weak frost resistance.
4. The distance from the street had clear influence on growth and frost resistance of studied plants that is why it is recommended to plant ground cover shrubs in distance not shorter than 1.7 m from the street kerbstone.

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TABLE 6. The results of the measurements and observations of the tested species and cultivars in particular years

Species, cultivar	Frost resistance [p.]*		Survival rate [%]		Heath rate [p.]**		Diameter increase [cm]		High increase [cm]		The pace of ground covering [%]	
	2004/2005	2005/2006	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Berberis thunbergii 'Atropurpurea'	5.4c***	2.3abc	98.7d	92.4d	8.3h	8.3d	9.2d	12.2ab	10.2g	11.9b	16.7d	19.2ab
Cotoneaster dammeri 'Eichholz'	0.4a	–	18.6a	0.0a	2.0a	–	–1.9b	–	0.0b	–	–11.1ab	–
Cotoneaster horizontalis	3.3b	1.6abc	95.3cd	29.2b	6.3d	2.3a	16.2f	12.1ab	7.0de	9.2ab	22.3de	–3.1a
Potentilla fruticosa 'Goldfinger'	4.5c	1.5ab	90.0c	54.7c	7.0f	4.1b	7.2d	8.9a	6.2d	7.0a	21.1de	20.6ab
Ribes alpinum 'Schmidt'	4.6c	2.1abc	96.6d	63.8c	6.3d	4.4b	8.3d	10.9a	7.6def	10.7ab	30.4e	45.7bc
Rosa rugosa	6.5d	4.7d	96.1cd	85.1d	6.7e	7.0cd	11.9e	15.9b	9.6fg	11.4ab	30.3e	58.4c
Spiraea japonica 'Anthony Waterer'	1.0a	–	61.2b	0.0a	3.0b	–	–6.7a	–	–12.0a	–	–32.0a	–
Spiraea japonica 'Froebelli'	7.8e	4.1cd	99.2d	95.3d	7.7g	8.3d	7.6d	22.6c	9.3efg	24.7c	24.7de	100.0d
Spiraea japonica 'Goldmound'	7.2de	3.1bcd	93.3cd	85.5d	7.0f	6.3c	7.2d	15.1b	5.7d	7.5a	14.6d	37.1bc
Stephanandra incisa 'Crispa'	1.3a	0.0a	63.1b	8.8ab	3.7c	–	2.0c	–	3.2c	–	6.4 c	–

– Complete lack of plants on the plot at the moment of testing.
* Scale: 0 – frozen plant, 10 – lack of damage.
** Scale: 0 – plants died or dying, 10 – healthy plants without major damages.
*** The same letters in row describe means which do not differ at the significance level p = 0.05, according to LSD test.

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Streszczenie: *Obserwacje mrozoodporności i wzrostu wybranych krzewów okrywowych w warunkach przyulicznych Warszawy*. Badania prowadzono w latach 2004–2005 na dziesięciu gatunkach i odmianach krzewów okrywowych. Rośliny zostały posadzone wiosną 2004 roku. Do badań wytypowano rośliny znajdujące się w tej samej odległości od jezdni w dwóch pasach: pierwszym odległym 0,5 m i drugim odległym 1,7 m od krawężnika. Każdy badany gatunek lub odmiana reprezentowana była przez trzy podobnie zlokalizowane poletka, z których każde traktowano jako powtórzenie. Na każdym poletku znajdowało się co najmniej 15 sztuk roślin. Niezależnie oceniono wpływ odległości od jezdni na poszczególne oceniane parametry roślin. Obserwacje i pomiary prowadzono oddzielnie na każdej roślinie, a wynik dla poletka uśredniano. W celu oceny wpływu odległości od jezdni na badane parametry ddzielnie uśredniano wyniki dla roślin rosnących bliżej i dalej od jezdni. Przez dwa sezony prowadzono pomiary parametrów biometrycznych roślin (średnica i wysokość) oraz prowadzono obserwacje przeżywalności roślin po każdym sezonie wegetacyjnym oraz uszkodzeń mrozowych po każdej zimie, a także oceniano zdrowotność roślin. Do oceny uszkodzeń mrozowych wykorzystano 11-stopniową skalę uszkodzeń mrozowych (0–10) stosowaną powszechnie przez ogrody botaniczne i arboreta, w której dokonano pewnych modyfikacji, tak by odpowiadała ocenie roślin okrywowych. Ocena zdrowotności roślin prowadzona była w aspekcie ich wartości estetycznych. Oceny dokonywano trzykrotnie w sezonie (początek czerwca, sierpnia i października) według opracowanej skali bonitacyjnej, uwzględniającej stopień porażenia przez choroby, szkodniki oraz objawy innych uszkodzeń na liściach lub pędach.

Uzyskane wyniki poddano analizie statystycznej (ANOVA). Grupy jednorodne wyróżniono testem LSD przy poziomie wiarygodności p = 0,05.

Końcowa klasyfikacja badanych gatunków i odmian potwierdziła wyniki poszczególnych badanych parametrów – po dwóch latach badań najwyżej oceniono *Spiraea japonica* ‘Froebelli’ (37,9 pkt), *Rosa rugosa* (32,8 pkt) i *Spiraea japonica* ‘Goldmound’ (30,3 pkt). Najsłabiej oceniono *Cotoneaster dammeri* ‘Eichholz’ (4,1 pkt), *Stephanandra incisa* ‘Crispa’ (6,9 pkt) i *Spiraea japonica* ‘Anthony Waterer’ (7,2 pkt). Odległość od jezdni wyraźnie wpływała na wzrost i mrozoodporność badanych roślin, dlatego zaleca się sadzenie krzewów okrywowych w odległościach nie mniejszych jak 1,7 m od krawężnika jezdni.

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