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Development of different herbaceous perennial species on the experimental extensive green roof of Corvinus University Budapest

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Summary: During 2003-2004 six "traditional" herbaceous plant species (*Sedum reflexum, Sedum acre* 'Aureum', *Sedum spurium, Sedum floriferum, Festuca glauca*) and six "new" plant species (*Sedum pulchellum, Prunus tenella, Hypericum polyphyllum, Ceratostigma plumbaginoides, Dianthus plumarius* and *Phlox subulata*) were tried on four different types of roof insulation on the 100 m^2 large experimental extensive green roof of the Building K of Corvinus University Budapest, at Villányi street, Budapest. According to the results obtained so far, the viability and good decoration values of all the "traditional" plants were proved. From the six "new" plants *Ceratostigma plumbaginoides, Dianthus plumarius* and *Sedum pulchellum* (with some restrictions) proved to be suitable. A significantly poorer development was showed by the remaining "new" species (*Phlox subulata, Hypericum polyphyllum, Prunus tenella*) than the "traditional" ones. As for the different types of roof insulation, the best was with the direct order of layers, and drainage layer with water storage capacity.

Key words: green roof, perennials, *Sedum*

Introduction

It is widely known and is a regrettable fact that green areas persistently decrease, mostly in big cities all over the world. In addition in the building industry flat roofs – both economically and environmentally the most underutilised assets of a city – have become a general technological solution, that eventuate "dead", biologically passive surfaces. There are growing worries therefore, about the environment.

More and more environmentalists believe to some of big cities' environmental problems the answer lies in the planting of green roofs. Using vegetation on roofs is not a modern invention. However, in the last decades, modern versions have been developed for the needs in modern cities today. Green roofs provide a large scale of benefits for the building itself, for the people living in them and for the climate of the city as well (*Dunnet & Kingsbury*, 2004).

In the recent years the planted flat roofs have been applied widely in Hungary too. It would be desirable to establish well-built green areas on the dead surfaces. For this, however, such species have to be used which can withstand and survive the special adverse conditions – long, hot and dry summers and cold winters – what an extensive green roof is typical of. So far, only a few species have been used on Hungarian extensive green roofs, mostly *Sedum* and *Sempervivum* species and cultivars. The reason is that these species are surely viable on these surfaces. The main object of the present studies was to find and test new species suitable for the hard, exposured habitats of green roofs (*Hidy* et al., 1995).

Another important object was to test the effects of different insulation types on the plantation. More and more technological methods are known and used, but there are no reliable data which insulation method is the most suitable for the development of the species. The main categories of insulation and drainage layer, and the effects of them on the plantation are shown in *Table 1*.

Table 1. The effects of different insulation types on the plantation (Source: Horváthné, 2004)

The technological layer		The effects on the plantation	
Order of layers	Type of drainage layer	Heat supply	Water supply
direct (3 cm thick thermal insulation)	with water storage capacity	+	+
reversed (3 cm thick thermal insulation)	without water storage capacity	+	–
direct (8 cm thick thermal insulation)	with water storage capacity	–	+
reversed (10 cm thick thermal insulation)	without water storage capacity	–	–

In the last few years the methods of green roofing became an important question of the researches. Many author are engaged in this topic, both in the general question of planning and construction of green roofs, and both the question of planting these roof surfaces. In general questions the most important authors are Grub (1986), Krupka (1992), Hidy et al. (1995), Horváthné (1999, 2003), Varga (2002) and Dunnet and Kingsbury (2004). The authors of the most important references of the plants of green roofs are Gerzson (1997, 2000, 2001, 2003), Schmidt (2000, 2003) and Zsohár and Zsohárné (2001).

Material and method

In the year 2003 a new experimental extensive green roof was established on the central building (K) of Buda Campus of Corvinus University Budapest with the support of the Hungarian Society of Green Roof Constructors.

During 2003–2004 testing of six "traditional" (*Sedum reflexum, Sedum acre* 'Aureum', *Sedum spurium, Sedum floriferum, Festuca glauca*) and six "new" plant species (*Sedum pulchellum, Prunus tenella, Hypericum polyphyllum, Ceratostigma plumbaginoides, Dianthus plumarius* and *Phlox subulata*) began on four different types of roof insulation on this 100 m^2 large surface. On each insulation types 2×12 plants (24 plots on each insulation types) were set from every species. The examination of the growing media was not the subject of the experiment. On each insulation type the depth of the growing media was 10 cm deep.

The different insulation types are:

1. Direct order of layers (with 3 cm thick thermal insulation) and drainage layer with water storage capacity
2. Direct order of layers (with 3 cm thick thermal insulation) and drainage layer without water storage capacity
3. Reversed order of layers (with 8 cm thick thermal insulation) and drainage layer with water storage capacity
4. Reversed order of layers (with 10 cm thick thermal insulation) and drainage layer without water storage capacity

With this experimental green roof it was possible to examine the development of the planted species, the survival rate and the spread of the plants in extreme circumstances, and furthermore the effects of the different technological layers on the plantation.

The examined parameters were:

- viability of species (the percentage of the remaining specimens);
- covering values 3 times (April, July, October) per year: the covered area by each specimens in cm^2, and the percentage of the covered area on each plots;
- flowering dynamics: 1–2 times per week from the appearance of the first flower buds, the number of the flowers and the length of the flowering period;
- spontaneous appearance of alien species, including weeds, 2 times (April, August) per year. Once per every year the most dangerous weeds have been removed.

Results

Effects of the different insulation types on the development of the plants

According to the results obtained up to now (*Figure 1*), differences can be demonstrated between the development of the plants on the four insulation systems.

On the base of the covering values of each species significant difference can be observed: the best was with the direct order of layers, and drainage layer with water storage capacity. This insulation type was significantly different from the other types. Smaller differences can be observed at the other insulation systems, but at 95% significance level this difference is irrelevant.

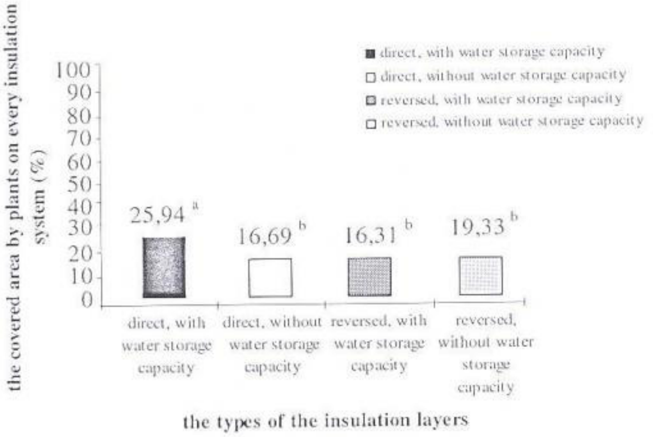

Fig. 1. Effects of the different insulation types on the development of the plants (Columns assigned by different letters differ significantly at level P=0.05) (2004)

The covering values of the species

Traditional plants: According to the obtained data, the good covering and decoration values of all the "traditional" plants proved during the first year of experiment. The best results were shown by *Sedum floriferum* and *Festuca glauca*. After all it have to be taken account of the ruination of few plants of *Festuca glauca* after an unusually long, dry and hot, or even more after a long, snow covered period.

New plant species: From the "new" plants *Ceratostigma plumbaginoides, Dianthus plumarius* and *Sedum pulchellum* proved to be suitable. Nevertheless, most of the originally set *Dianthus plumarius* plants died out in 2004, but in 2005 many seedlings (more viable) were observed. *Ceratostigma plumbaginoides* proved to be suitable only on two insulation types (direct order of layers, drainage layer with water storage capacity (A) and reversed order of layers with drainage layer without water storage capacity (B). Its covering values were similar to the "traditional" ones. Unfortunately, the reasons of the fact (why on that two insulation layers which means extremity of the others is the development of the plants better) is unanswered yet, another experimental periods needed. In addition to these species

Table 2. The covering values of each species on the different roof areas (2004)

Surveys	16.03.2004				15.05.2004				01.09.2004.			
	Covering values (%) on the insulation systems											
	Direct		Reversed		Direct		Reversed		Direct		Reversed	
	Drainage layer											
Species	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity
Sedum reflexum	13.36	15.24	13.04	10.92	28.63	34.16	23.02	19.77	44.88	35.56	26.5	30.4
Sedum acre 'Aureum'	16.85	13.99	16.83	16.42	43.99	27.73	33.3	28.57	44.39	28.1	33.1	34.53
Sedum spurium	9.4	7.69	8.13	7.47	24.47	23	18.4	16.4	34.53	31.46	34.43	31.27
Sedum floriferum	20.53	17.8	17.43	17.06	36.5	37.03	29.53	26.8	51.57	44.67	48.5	45.6
Sedum pulchellum	15.97	13.17	15.6	15.47	46.3	34.03	54.37	45.9	0	0	0	0
Sempervivum cultivars	10	1.05	7.47	9.57	17.17	16.7	17.47	19.1	22.73	23.63	25.3	27.1
Festuca glauca	20.57	17.5	15.17	16.1	51.73	35.8	27.83	36.83	51.73	35.8	27.83	36.83
*Prunus tenella**	24	11	12	13	5	3	6	5	2	0	0	0
Ceratostigma plumaginoides	0	0	0	0	15.5	3.13	1.13	5	42.47	0	0	7.43
Hypericum polyphyllum	16.17	14.07	13.87	13.33	35.43	36.23	19.16	19.53	12.43	0	0	9.5
Dianthus plumarius	11.7	11.7	14.33	13.77	17.67	16.6	18.16	17.57	3.58	1 db	0	8.27
Phlox subulata	15.6	16.8	16.6	15.6	24.2	24.07	21.13	26.6	2 plants	0	0	1 plants

* The number (by the piece) of the surviving specimens.

Sedum pulchellum seems to be suitable even though it germinated late autumn, and after a great flowering period in late May the plant shrivelled. On the whole a significantly poorer development was showed by the other species than the "traditional" ones. Unfortunately *Prunus tenella* disappeared from the green roof.

The reasons can be different:

- shortage of precipitation
- thin growing media
- the low level of nutrients in the growing media
- plants (bare-rooted suckers) were not suitably prepared.

It has to be taken into consideration that special planting methods (for example transplanting from extreme areas) should be tried out on extensive green roofs instead of containered plants. That could be the solution for these species to survive the extreme conditions on roof surfaces.

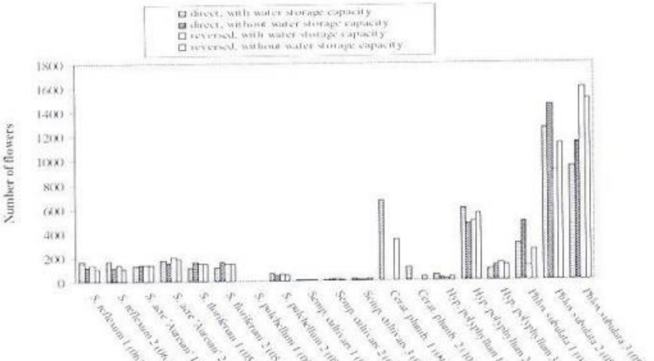

Fig. 2. Number of flowers of each species on different insulation types on the experimental green roof of Corvinus University Budapest (2004)

The flowering dynamics of the species

The flowering features of the species are important, mostly on visible green roofs. This feature (both type and colour of the flowers and the length of the blooming period) increase the aesthetic value.

Good flowering data were observed at most of the species. Only flowers were not developed by the plants of *Sedum spurium*, supposedly because of the long dry summer period in 2004 (the results are shown in *Figure* 2).

Significant differences were shown only by *Dianthus plumarius* (the results are shown in Figure 3.) There were difference between the number of flowers and the beginning of the blooming periods on the different roof areas.

Appearance of alien species, weeds

In 2004 a few dangerous species occured on the experimental extensive green roof (the results are shown in *Table 3*). By the annual weeding these species were – and have to be removed in the future – removed. Extremely dangerous are those new-comer species, which initial development is quick and are able to damage the insulation systems, for example *Acer negundo*. On every green roof weeding has to be taken into account as an important running

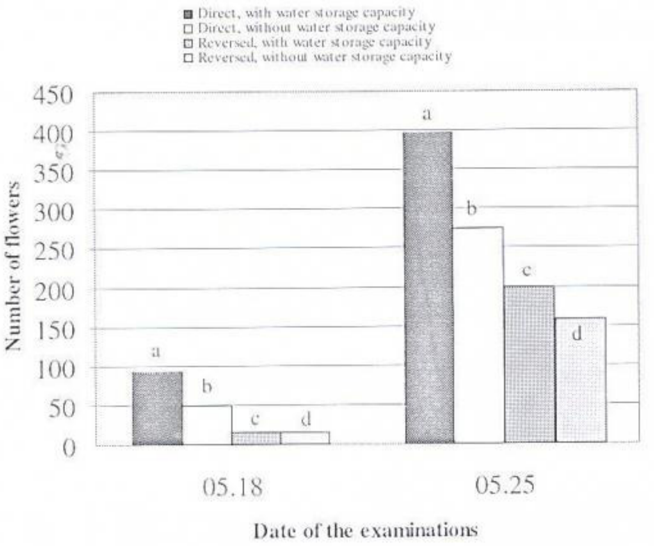

Fig. 3. Intensity of flowering of *Dianthus plumarius* on different insulation layers on the experimental green roof of Corvinus University Budapest (Columns assigned by different letters differ significantly at level P=0.05) (2004)

expense. Without this minimal maintenance the insulation system of the green roofs can be seriously damaged by the dangerous weed species.

On extensive green roofs one of the most important aims is the creation of an ecological protection layer with different plant species. By reaching this aim important can be the different, spontaneously appearing species, weeds too. But also the occurance of dangerous weeds has to be taken into consideration.

According to the evaluated data no significant difference can be observed between the weeding procession on the different insulation layers.

In 2005 new plants appeared on the experimental roof. These plants are *Sedum album*, *Sedum hybridum* and *Allium tuberosum*. Only few of them appeared and the examination of the development of these species will be one of our task in the future. Supposedly these species will be such important as the originally planted ones in the development of the plantation of the extensive green roof.

Conclusions

By the evaluating of the results it has to be taken into consideration that the data are from the first year of the experiment. Data of minimum 3 years should be analyzed to get exact data for generalization.

According to the data from the first year the viability and good decoration values of all the "traditional" plants were proved. From the 'new' species *Dianthus plumarius*, *Ceratostigma plumbaginoides* and *Sedum pulchellum* are promising, but all the "new" plants need further examinations.

From the different insulation systems the one with the direct order of layers, and drainage layer with water storage capacity was proved to be the best after the first year.

The amount of the appearing weed species was low, but many on these species were dangerous weeds which had to be removed. In addition some new spontaneously settled species (*Sedum album*, *Sedum hybridum*, *Allium tuberosum*) were found which can play important rule in the creation of the ecological protection layer.

Table 3. The most occurent weed species on different insulation layers on the experimental green roof of Corvinus University Budapest (2004)

Data of examinations	20.04.2004				25.05.2004				20.09.2004			
	Number of plants on the different insulation layers											
	Direct		Reversed		Direct		Reversed		Direct		Reversed	
	Drainage layer											
Weed species	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity	with water storage capacity
Acer negundo	5	10	9	5	22	14	20	19	0	0	0	2
Ambrosia elatior	0	0	0	1	6	14	18	22	0	3	0	1
Buddleia davidii	0	0	0	0	0	0	0	0	8	31	12	91
Chenopodium album	4	0	0	0	60	39	83	58	6	6	9	6
Polygonum aviculare	5	0	0	0	42	62	43	37	1	0	0	5
Portulaca oleracea	1	7	0	0	0	1	0	0	73	87	160	89
Robinia pseudoacacia	0	0	0	0	1	2	1	0	1	0	0	0

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