Sewage Sludge Compost as Potting Media Component for ivy Pelargonium (*Pelargonium peltatum* (L.) L'Her.) Production

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Abstract: The increasing demand and raising cost of high quality peat for horticultural use have led to search for low cost substrates as an alternative. The source of materials for their production can be various types of industrial, municipal and agricultural waste. Most of them are rich in organic matter and minerals essential for plant growth. The aim of the study was to evaluate the growth and flowering of two ivy pelargonium cultivars ('Beach' and 'Boneta') grown in the media containing sphagnum peat and composts made from municipal sewage sludge and structure-forming components. Two different types of composts were used, consisting in equal proportions of sewage sludge and straw (SSRS) or leaves (SSL). The composts replaced 25% or 12.5% of sphagnum peat (v/v) in the growth media. A control media was sphagnum peat (100%) supplemented with a mixed fertilizer.

It was found that the media containing both types of compost might be useful for growing ivy pelargonium. The most beneficial effect on the growth, foliage, and a decorative value of the pelargonium was observed for the medium containing 12.5% of SSL compost and 87.5% of peat. Decorative value of the pelargonium grown in the medium with 25% of SSL compost or with either dose of SSRS compost, did not differ from the control plants. The investigated cultivars differed in the number of shoot, color and area of leaves as well as length of stem of inflorescence. 'Boneta' cv. developed more stems and had greener leaves than those from 'Beach' cultivar. While cultivar 'Beach' had greater area of leaves per plant and longer stem of inflorescence.

Keywords: Bedding plants, decorative values, growing media, ornamental plant, sphagnum peat, rye straw, waste material.

INTRODUCTION

In recent years, Europe has experienced a significant decrease in the reserves of sphagnum peat, the primary substrate for floriculture. The economic and ecological factors made the researchers look for and develop other growth media, providing an alternative to peat [1, 2]. Ingredients for such media are sought mainly among various types of industrial, municipal and agricultural waste [3-6]. These waste materials may be useful in preparing growth media for the ornamental plant species highly tolerant to salinity and high content of certain minerals [7]. Natural growth media are especially widely used in the production of potted plants. Vegetatively and generatively propagated pelargoniums are a group of plants, which in 2013 were the most often sold on Dutch markets as potted plants for decoration of balconies and flowerbeds [8]. They are commonly regarded by many researchers as plants tolerant to salinity and elevated levels of certain trace elements. The use of growth media supplemented with waste products in the production of potted plants may therefore be helpful in saving the valuable resources of sphagnum peat [1, 9, 10].

The aim of this study was to evaluate the growth and flowering of two cultivars of ivy pelargonium ('Beach' and 'Boneta') grown in the media containing composts made of sewage sludge and straw or leaves.

MATERIAL AND METHODS

Plant material included rooted cuttings of two cultivars of ivy pelargonium: 'Beach' from Fischer culture, and 'Boneta' from Geranien Endisch - both with dark red, semi-double, velvety flowers. In the third decade of April 2010, the cuttings were planted into pots (ø 12 cm) in media containing two types of composts, prepared according to the method described as GWDA [11]. In this method, composted materials is deposited in heaps, which are aerated by perforated pipes placed at a base of the heap. The composts were obtained from Municipal Sewage Treatment Plant in Stargard Szczeciński and they consisted, in equal proportions, of sewage sludge and straw (SSRS compost) or leaves (SSL compost). The composting process was run for 14 months. Growth media based on the composts were prepared 4 weeks prior to planting. The composts were mixed with sphagnum peat in two volume proportions: 25% compost, 75% sphagnum peat and 12.5% compost, 87.5% sphagnum peat. Control pelargoniums were planted into sphagnum peat (100%) neutralized with chalk and dolomite to pH of 5.8-6.0 and supplemented with

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fertilizer Azofoska (13.6% N + 6.4% P_2O_5 + 19% K_2O + 4.5% MgO + micronutrients), at a dose of 2.5 g·dm^{-3}.

Growth media composition was as follows:

1. control – 100% sphagnum peat + Azofoska 2.5 g·dm^{-3}
2. 25% SSRS compost + 75% sphagnum peat
3. 12.5% SSRS compost + 87.5% sphagnum peat
4. 25 % SSL compost + 75 % sphagnum peat
5. 12.5 % SSL compost + 87.5 % sphagnum peat

Given the results of chemical analyses of the prepared composts media (Table **1**), lacking nitrogen and potassium were supplemented with ammonium nitrate(V) and ammonium sulphate to the level recommended for pelargonium by Komosa [12]. From June until mid-August 2010, the plants were watered once a week with 0.2% solution (100 ml per pot) of Peters Professional mixed fertilizer (27% N + 15% P + 12% K). During the study plants were grown under a plastic tunnel, in the conditions meeting their growth requirements [13]. The experiment was fully randomized and run in four replicates, three plants per replicate.

Morphological traits (number of shoots and length of the longest shoot, diameter of flowers and inflorescences, number of flowers per inflorescence, and length of the inflorescence stem) and bonitation were evaluated in the flowering stage. The bonitation assessment was based on a 5-point bonitation scale. The highest score (5) was given to the pelargoniums with the highest ornamental value, and the lowest (1) to the plants showing no such value. For 10 weeks of flowering, inflorescences were counted (every 10 days) and then removed. The number of inflorescences are given per one plant. Leaf assimilation area was measured with Delta-T Image Analysis System analyzer (DIAS, Delta-T Device Ltd., Cambridge, Great Britain). The device records images by means of a special analog to digital converter coupled to a PC. The same leaves were used to determine their fresh weight and number. Leaf chlorophyll content measurements (SPAD) were performed using an optical method with Chlorophyll Meter SPAD-502 (Minolta, Japan).

The results for morphological traits were analyzed statistically by means of two-factor analysis of variance in Statistica 10.0 software. Significance of mean values was verified by Tukey's test at a significance level $P \leq 0.05$.

RESULTS AND DISCUSSION

Composts made of sewage sludge are characterized by high content of nitrogen and phosphorus with respect to potassium [14], and high concentration of salt [15]. Their unfavourable pH and high salt content are main factors limiting their use [16], especially in seedling production [17]. Not all composts can be used directly as growth media, but they can be mixed with other components [18, 19].

Composts made of municipal sludge and straw or sawdust were found to be useful growth media for many ornamental plant species [20-22], including zonal pelargonium [23]. According to Biamonte *et al.* [24], ivy pelargonium is more sensitive to salinity (1.0-2.0 mS·cm^{-1}) than zonal pelargonium (1.5-2.5 mS·cm^{-1}) and it requires a slightly lower pH of the medium. Morphological traits important in the production of this species include good branching, healthy and abundant foliage and a large number of inflorescences attached to not very long inflorescence stems.

Table 1: Chemical Properties of the Substrate Media Used for the Cultivation of ivy Pelargonium

Media	pH_{H2O}	Content (mg·dm^{-3})						Salinity g NaCl·dm^{-3}
		$N\text{-}NO_3$	P	K	Ca	Mg	Cl	
1[x]	4.6	22	32	26	490	92	37	0.24
2	6.6	18[N]	778	430	1294	201	69	1.65
3	5.8	26[N]	335	225[K]	702	136	45	0.82
4	7.5	17[N]	582	398	2698	368	82	2.18
5	6.4	15[N]	376	272[K]	1581	221	55	1.31

Explanations:
[x]1 - sphagnum peat 100%; 2 - SSRS compost 25%, sphagnum peat 75%; 3 - SSRS compost 12.5%, sphagnum peat 87.5%; 4 - SSL compost 25%, sphagnum peat 75%; 5 - SSL compost 12.5%, sphagnum peat 87.5%; SSRS – sewage sludge, rye straw (1:1, v/v); SSL – sewage sludge, leaves (1:1, v/v).
[N]media supplemented with nitrogen to the level of 280 mg $N\text{-}NO_3$·dm^{-3}; [K] media supplemented with potassium to the level of 350 mg K·dm^{-3}.

Table 2: Effect of the Compost Media on the Growth of ivy Pelargonium

Factor		Number of stems	Length of stem [cm]
Media	1[x]	3.40 ± 0.52 b[y]	38.4 ± 3.47 a
	2	3.65 ± 0.66 ab	36.1 ± 4.05 a
	3	3.00 ± 0.47 b	28.0 ± 4.34 bc
	4	3.05 ± 0.64 b	26.0 ± 3.84 c
	5	4.15 ± 0.53 a	31.2 ± 2.52 b
Cultivar	Beach	3.24 ± 0.71 b	31.7 ± 6.11 a
	Boneta	3.66 ± 0.62 a	32.2 ± 5.90 a
Effect significance:			
media		***	*
cultivar		**	ns
media × cultivar		ns	ns

Explanations:
[x]1 - sphagnum peat 100%; 2 - SSRS compost 25%, sphagnum peat 75%; 3 - SSRS compost 12.5%, sphagnum peat 87.5%; 4 - SSL compost 25%, sphagnum peat 75%; 5 - SSL compost 12.5%, sphagnum peat 87.5%; SSRS – sewage sludge, rye straw (1:1, v/v); SSL – sewage sludge, leaves (1:1, v/v).
[y]values represent the means of four replications ± standard deviations; means marked with the same letters in columns do not differ significantly at $P \leq 0.05$ according to Tukey multiple range test.
* effect significance at the level $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.
ns – not significant.

In our study, ivy pelargonium had more shoots when grown in the medium containing 12.5% of SSL compost (Table **2**). The plants grown in medium No. 2, containing 25% of SSRS compost had fewer shoots, but the difference was not significant. Pelargonium shoot length in the medium No.2 was not significantly different from the shoots of control plants, which were the longest. Shorter shoots were found in the plants grown in the medium with 25% content of SSL compost. The investigated cultivars did not differ in shoot length, but higher number of shoots (mean 0.4) was observed in 'Boneta' plants.

Ivy pelargoniums grown in the medium supplemented with 12.5% of SSL compost had the highest number of leaves (52.4), but were not statistically different in this regard from the plants grown in the media containing 25% of SSRS compost (Table **3**). The plants grown in the medium containing 12.5% of SSL compost had by 22% more leaves than the control ones. These pelargoniums also had the greenest leaves, but significant differences in SPAD index were found only in relation to the plants growing in the media with 25% of SSL compost. Positive effects of the growth media containing sewage sludge on foliage abundance were reported in poinsettia [25] and boxwood [26].

The pelargoniums grown in the media containing sewage sludge and SSL compost had, regardless of

Table 3: Effect of the Compost Media on the Foliage of ivy Pelargonium

Factor		Number of leaves	Greeness index of leaves (SPAD)	Area of leaves per plant (cm^2)	Fresh matter of leaves (g)
Media	1	42.9 ± 4.22 bc	44.2 ± 4.36 ab	1859.0 ± 468.3 a	200.5 ± 37.0 a
	2	44.7 ± 4.35 ab	44.5 ± 2.41 ab	1420.5 ± 122.4 b	136.8 ± 14.2 b
	3	36.5 ± 5.42 c	44.0 ± 3.04 ab	1186.7 ± 163.2 b	119.0 ± 9.65 b
	4	42.2 ± 7.22 bc	43.4 ± 3.14 b	1986.3 ± 106.0 a	195.7 ± 15.5 a
	5	52.4 ± 8.48 a	47.1 ± 2.37 a	1944.2 ± 214.7 a	210.2 ± 30.3 a
Cultivar	Beach	43.8 ± 8.16 a	43.2 ± 3.00 b	1758.6 ± 439.6 a	174.5 ± 47.5 a
	Boneta	43.6 ± 7.69 a	46.1 ± 2.92 a	1600.3 ± 352.4 b	170.4 ± 41.0 a
Effect significance:					
media		***	*	***	***
cultivar		ns	***	*	ns
media × cultivar		ns	ns	ns	ns

Explanations: see Table **2**.

Table 4: Effect of the Compost Media on the Flowering of ivy Pelargonium

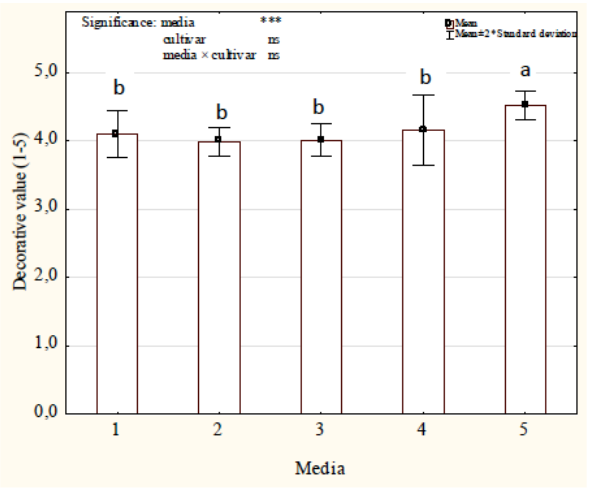
Factor		Diameter of inflorescence (cm)	Length of stem of inflorescence (cm)	Number of flowers in inflorescence	Diameter of flower (cm)	Number of inflorescences
Media	1	8.75 ± 0.43 b	20.6 ± 3.85 ab	12.6 ± 2.57 b	4.67 ± 0.27 ab	21.1 ± 3.70 a
	2	8.85 ± 0.44 ab	21.5 ± 3.77 a	16.2 ± 3.30 a	4.51 ± 0.18 b	17.6 ± 2.98 b
	3	8.85 ± 0.86 ab	21.2 ± 2.30 ab	14.3 ± 2.66 ab	4.73 ± 0.29 ab	15.9 ± 4.63 b
	4	9.34 ± 0.34 a	20.7 ± 3.61 ab	12.6 ± 2.11 b	4.87 ± 0.30 a	18.3 ± 2.43 ab
	5	9.35 ± 0.74 a	17.6 ± 1.31 b	14.4 ± 2.30 ab	4.92 ± 0.12 a	18.3 ± 2.55 ab
Cultivar	Beach	8.97 ± 0.54 a	21.3 ± 2.85 a	14.7 ± 3.27 a	4.79 ± 0.28 a	18.8 ± 3.95 a
	Boneta	9.09 ± 0.72 a	19.4 ± 3.56 b	13.3 ± 2.26 a	4.70 ± 0.27 a	17.7 ± 3.28 a
Effect significance:						
media		**	***	**	**	*
cultivar		ns	***	ns	ns	ns
media × cultivar		ns	*	ns	ns	ns

Explanations: see Table **2**.

SSL dose, greater leaf assimilation area and leaf fresh weight than those growing in SSRS compost, but they did not differ in this respect from the control plants. Both cultivars had similar number of leaves and leaf fresh weight. The leaves were greener in 'Boneta' plants, but their assimilation area was greater in 'Beach' cultivar. Composted sewage sludge added to gardening soil substrates may improve plant fresh and dry weight, as reported in the studies on *Tagetes erecta* [27], *Chrysanthemum* × *grandiflorum* [28], *Euphorbia pulcherrima* [25] and *Carpobrotus edulis*, *Aptenia cordifolia* or *Bryophyllum tubiflorum* [29]. Increased leaf assimilation area was described in such plants as *Ruscus hypophyllum* [30] and *Chrysanthemum* × *grandiflorum* [28], grown in a substrate containing sewage sludge and compost (1:4) made of the leaves and trunk of *Elaeis guineensis*.

The plants grown in the media with SSL compost had, regardless of compost dose, the largest inflorescences, but they were not statistically different from the inflorescences of pelargoniums growing in the media with SSRS compost. The smallest inflorescence diameter was observed in control plants (Table **4**). The greatest number of flowers per inflorescence was found in the pelargoniums grown in the media with higher dose of SSRS compost, and they were by 28% less abundant in the control plants. The number of flowers per inflorescence, developed in the plants grown on other media, was not significantly different from control. The shortest inflorescence stems were seen in the ivy pelargoniums growing in the media No. 5, containing 12.5% of compost from sewage sludge and leaves (SSL). No significant differences in the length of inflorescence stems were found for other media and the control substrate. The plants grown in the medium supplemented with SSL compost developed larger flowers than those grown in the medium No. 2, but flower diameter was not significantly different from control plants and the plants grown in the medium with 12.5% of SSRS compost.

Dahlia hortensis 'Figaro' plants, grown in the media containing 50% or 100% sewage sludge, had smaller inflorescence diameter than control plants and their flowering was delayed. Moreover, a negative effect of sewage sludge on the number of flowers was reported [31]. In our study, the most abundant flowering was observed in the control pelargoniums that developed



Explanations: see Table 2

Figure 1: Decorative value of ivy pelargonium cultivated in the composts media.

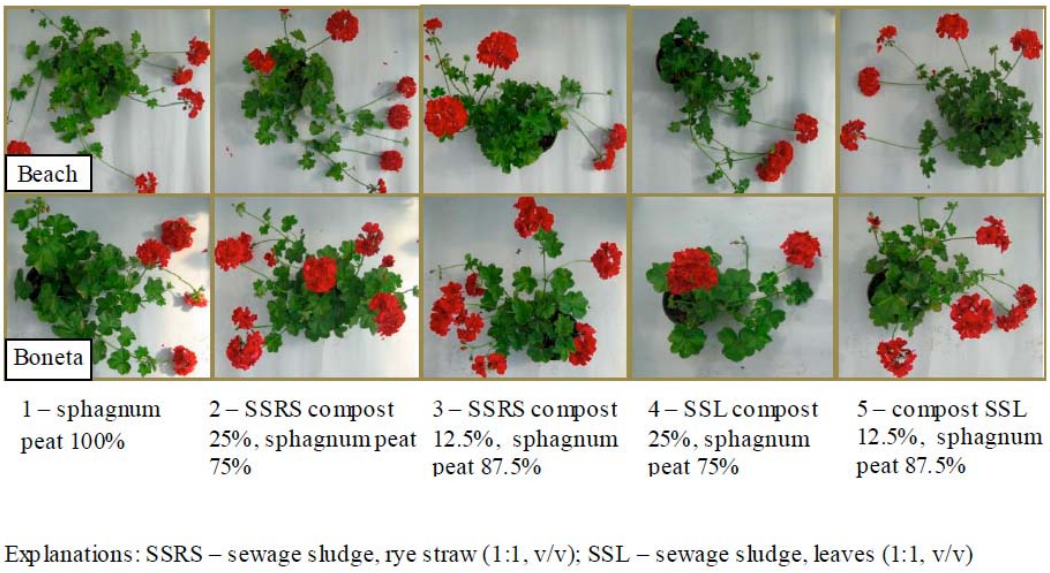


Figure 2: Comparison of ivy pelargonium 'Beach' and 'Boneta' cultivated in composts media.

an average of 21.1 inflorescences. The plants grown in substrates supplemented with SSL compost had, irrespective of its dose, by 2.8 inflorescences fewer, but the differences were not significant (Table **4**). Grigatti *et al.* [32] found a decreasing number of flowers in *Begonia semperflorens*, *Mimulus* ssp., *Salvia splendens* and *Tagetes* 'Zenith Lemon Yellow' when increasing the share of sewage sludge in the growing medium (from 25 to 100 %). However, the lowest dose of the sludge had a positive effect on flowering in these taxa. The investigated pelargonium cultivars differed only in the length of inflorescence stem. They were on average 1.9 cm longer in 'Beach' than in 'Boneta' plants (Table **4**).

Regardless of the cultivar, the highest ornamental value was seen in the plants grown in the medium containing 12.5% of SSL compost (Figure **1**). The plants had abundant and intensely green leaves, large flowers and short inflorescence stems (Figure **2**). The ornamental value of plants grown in the other media was similar.

Introduction of the investigated substrates into a production of ornamental plants, such as ivy pelargonium, grown in Europe on a large scale, may bring economic and environmental benefits, primarily through saving traditional substrates and partial disposal of problematic waste.

CONCLUSIONS

1. Substrates containing composts made of sewage sludge and straw or leaves are useful for growing ivy pelargonium.
2. The most beneficial effect on the growth, foliage, and a decorative value of ivy pelargonium was observed for the medium containing 12.5% of the compost made of sewage sludge and leaves (SSL) and 87.5% of sphagnum peat. Ornamental value of the pelargonium grown in the medium with 25% of SSL compost or the compost made of sewage sludge and straw (SSRS), did not differ from the control plants.
3. Flowering abundance, manifested by the number of inflorescences developed by ivy pelargonium grown in the media supplemented with the compost made of sewage sludge and leaves (SSL), was similar as in control plants.
4. Pelargonium 'Boneta' cv. developed more stems and had greener leaves whereas pelargonium 'Beach' cv. had greater area of leaves per plant and longer stem of inflorescence.

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