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EFFECT OF SUBSTRATES CONTAINING MUNICIPAL SEWAGE SLUDGE COMPOST ON THE ACCUMULATION OF MACROCOMPONENTS IN *IMPATIENS WALLERIANA* HOOK

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Abstract

Municipal sewage sludge is often used in compost production for agriculture. Composting sediments, which include structure-forming materials, results in the formation of matter rich in organic substances and nutrients that can be used as a component of horticultural substrates, as an alternative to peat. The aim of this research paper is to assess the impact of substrates containing municipal sewage sludge compost on $N_{tot.}$, P, K, Ca, Mg and S levels in the leaves and roots of *Impatiens walleriana* Hook. The two-year experiment used four types of compost; in the first year the tests were conducted after a 7-month period of decay and the second year after an 18-month period. The composition of compost material was as follows: compost I – 70% municipal sewage sludge, 30% rye straw; compost II – 70% municipal sewage sludge, 30% coniferous tree sawdust; compost III – 35% municipal sewage sludge, 35% potato pulp, 30% rye straw; compost IV – 35% municipal sewage sludge, 35% potato pulp, 30% coniferous tree sawdust. During the first and second year, five experimental sites were used: four substrate with 50% of the tested compost and 50% sphagnum peat and one sphagnum peat reference substrate with a 2.5 g dm^{-3} dose of Azofoska multipurpose fertiliser.

After 12 weeks of *Impatiens walleriana* cultivation the recorded level of total nitrogen, calcium, magnesium and sulphur in the leaves was lower than the optimal range of the macrocomponent content recommended for this species. The levels of phosphorus and potassium were the exception. Impatiens cultivated in substrates with compost after a 7-month decay period contained 1.7 times more nitrogen and 1.8 times more potassium in the leaves; they had similar phosphorus and sulphur content and lower calcium and magnesium content than the plants cultivated in the compost substrates after an 18-month decay period. The roots of impatiens contained more calcium than the leaves in both years of the study.

The nutrients supplied in the substrates and through top dressing fertilisation were not sufficient to achieve the best cultivation results for *Impatiens walleriana*.

Keywords: composts, sewage sludge, *Impatiens waleriana* Hook., macrocomponents.

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WPŁYW PODŁOŻY ZAWIERAJĄCYCH KOMPOSTY Z KOMUNALNEGO OSADU ŚCIEKOWEGO NA AKUMULACJĘ MAKROSKŁADNIKÓW W NIECIERPKU WALLERIANA (*IMPATIENS WALLERIANA* HOOK.)

Abstrakt

Komunalne osady ściekowe są odpadem wykorzystywanym często w rolnictwie do produkcji kompostów. Kompostowanie osadów z materiałami strukturotwórczymi powoduje, że powstaje bogata w substancję organiczną i składniki pokarmowe materia, którą można stosować alternatywnie do torfu, jako składnik podłoży ogrodniczych. Celem pracy była ocena wpływu podłoży zawierających komposty z komunalnych osadów ściekowych na zawartość N_{og}., P, K, Ca, Mg, S w liściach i korzeniach niecierpka Walleriana. W doświadczeniu dwuletnim wykorzystano cztery rodzaje kompostów: w pierwszym roku po 7- miesięcznym okresie rozkładu, a w drugim po 18-miesięcznym okresie rozkładu. Skład rzeczowy kompostów był następujący: kompost I – 70% komunalny osad ściekowy, 30% słoma żytnia; kompost II – 70% komunalny osad ściekowy, 30% trociny z drzew iglastych; kompost III – 35% komunalny osad ściekowy, 35% wycierka ziemniaczana, 30% słoma żytnia; kompost IV – 35% komunalny osad ściekowy, 35% wycierka ziemniaczana, 30% trociny z drzew iglastych. W pierwszym i drugim roku zastosowano pięć obiektów doświadczalnych: cztery podłoża z udziałem 50% danego kompostu i 50% torfu wysokiego oraz jedno podłoże kontrolne z torfu wysokiego, z dodatkiem Azofoski w dawce 2,5g dm^{-3}.

Po 12 tygodniach uprawy niecierpka Walleriana zawartość azotu ogólnego, wapnia, magnezu i siarki w liściach, z wyjątkiem fosforu i potasu, była mniejsza niż optymalny zakres zawartości tych makroskładników zalecany dla tego gatunku. Niecierpki uprawiane w podłożach z udziałem kompostów po 7-miesięcznym okresie rozkładu gromadziły w liściach 1,7 razy więcej azotu ogólnego i 1,8 razy więcej potasu, miały podobną zawartość fosforu i siarki, natomiast mniej wapnia i magnezu niż w podłożach z kompostami po 18-miesięcznym okresie rozkładu. Korzenie niecierpka zawierały więcej wapnia niż liście w obydwóch latach badań. Składniki pokarmowe dostarczone w podłożach i w nawożeniu pogłównym nie zaspokoiły w pełni wymagań niecierpka Walleriana.

Słowa kluczowe: kompost, osad ściekowy, niecierpek Walleriana, makroskładniki.

INTRODUCTION

Impatiens walleriana Hook. is an ornamental plant originating from Africa. In Poland, it is primarily grown on flowerbeds and as a cover plant in parks and gardens. It is characterized by rapid growth, abundant flowering and lasting ornamental value.

Peat is the most common substrate in the cultivation of bedding plants (Rumpel 1998, Ribeiro et al. 2007). Alternative substrates developed from different types of industrial and municipal waste are becoming increasingly popular due to environmental and economic considerations (Grigatti et al. 2007, Krzywy et al. 2007, Zaller 2007). These types of waste are rich in organic substances and contain elements that may provide plants with necessary nutrients. Municipal sewage sludge can also be used for this purpose (Ribeiro et al. 2000, Zubilaga, Lavado 2001) despite a number of limitations as to its use, including an unpleasant odour, greasy texture and, most importantly, excessive concentrations of heavy metals and pathogens

(Dusza et al. 2009). Therefore, before it is used for plant growing, the waste must comply with the requirements set out in the Polish legislation (*Regulation*…2008, *Regulation*…2010). Composting is the most effective and economic method of sewage treatment (Raviv 1998, Ciećko, Harnisz 2002). Composts based on municipal sewage sludge are very rich in macro-and micronutrients; on the other hand, they may present an elevated pH and salinity (Kalembasa, Kuziemska 1999, Baran 2004), which is why they should be mixed with other less rich substrates, e.g. peat (Abad et al. 2001, Moore 2004).

The study was conducted in order to evaluate the effect of substrates containing peat and municipal sewage sludge compost, potato pulp, and straw or sawdust on the macronutrient content of leaves and roots of *Impatiens walleriana*.

MATERIAL AND METHODS

A study on *Impatiens walleriana* was conducted in 2005-2006. It involved analyses of sphagnum peat and compost prepared in 2004from municipal sewage sludge, potato pulp, straw or sawdust. The plant material consisted of *Impatiens walleriana* seedlings of the variety Fiesta Lavendr Orchid, obtained from the Ball FloraPlant nurseries. Four variants of compost were added to the substrate, left to mature for seven months (in 2005) and for eighteen months (in 2006). The four variant composts had the following composition (in percentage of dry weight):

- compost I – 70% municipal sewage sludge, 30% rye straw;
- compost II – 70% municipal sewage sludge, 30% coniferous tree sawdust;
- compost III – 35% municipal sewage sludge, 35% potato pulp, 30% rye straw;
- compost IV – 35% municipal sewage sludge, 35% potato pulp, 30% coniferous tree sawdust.

The origin of the above materials, their chemical composition, descrption of the composting process and detailed chemical characteristics can be found in Krzywy et al. (2007). In early April 2005, four substrate mixtures were prepared from sphagnum peat and one of the four compost variants each (50% of volume). The reference consisted of peat substrate, whose pH was 6.0, with an addition of 2.5 kg m^{-3} of the fertilizer Azofoska (13.6+6.4+19.1). Results of chemical analyses of the substrates and their constituents material are presented in Table 1. The substrates whose pH was assessed as too low were neutralized with chalk and dolomite up to pH 5.8-6.0. Some substrates with the content of ammonium nitrate (V) and potassium below recommended values were supplemented with ammonium sulphate and potassium sulphate to the upper recommended level for impatiens. The plants were seeded in the substrates in the first ten days of June; 0.75 dm^3 capacity pots were placed in a plastic tunnel. Top dressing of all variants was performed after 7 weeks of the experiment in the first year and after 4 weeks in the second year. The plants were supplemented once weekly with 50 ml of Peters Professional (27+15+12) fertilizer per pot, in 0.5% concentration.

In both years, after 12 weeks of cultivation, plant material was sampled for chemical analysis. The slevel of $N_{tot.,}$ P, K, Ca, Mg and S were determined in leaves and roots. The plant material for analysis was obtained by taking pooled samples from all plants in each variant. The tests were made on samples dried at 60°C using the methods generally adopted in agricultural chemistry and pedology (Ostrowska et al. 1991, Nowosielski 1988).

In both years, the experiments were established in complete randomization with 4 replications, each comprising 4 plants. The results of analyses of the chemical composition of plants were verified with the help of the ANALWAR 4.3. software and variance analysis for univariate experiments. The significance of the means was verified with the Tukey's range test at a level of α = 0.05.

RESULTS AND DISCUSSION

Impatiens walleriana requires lightweight, permeable substrates with high water holding capacity (Kessler 2005). A German company called Benary (www.benary.com), which produces *Impatiens walleriana*, states that these plants respond well to 15-30% of clay and 0-20% of perlite added to the peat base. It is also recommended to use 1-1.5 kg m^{-3} of balanced multi-component fertilizer for supplementation of the levels of nutrients. The substrates prepared from compost containing municipal sewage sludge were rich in nutrients in both years of the study (Table 1). Composts used for preparation of the substrates did not exceed standards for the heavy metal content (Krzywy et al. 2007).

Impatiens walleriana has moderate nutritional requirements but it is sensitive to soil salinity. There are no precise data available on the optimal nutrient content in substrate for this species. Zawadzińska et al. (2009) presents general guidelines for growing *Impatiens* sp. According to her recommendations, the preferred salinity of soil for impatiens crops should be maintained below 2.5 g NaCl dm^{-3} and the pH between 5.5 and 6.5. The range of nutrients is as follows: 180-230 mg $N\text{-}NO_3$ dm^{-3}; < 40 mg $N\text{-}NH_4$ dm^{-3}; 160-210 mg P dm^{-3}; 200-250 mg K dm^{-3}; 500-1500 mg Ca dm^{-3}; 150-200 mg Mg dm^{-3}; 50-100 mg $S\text{-}SO_4$ dm^{-3}.

When analyzing the substrate prepared in 2005 (Table 1), a slightly lower pH than recommended for *Impatiens* was recorded; the salinity, on the

Table 1

Physical properties and chemical composition of substrates used for cultivation of *Impatiens walleriana* in 2005-2006

Substrate*	pH_{H_2O}	Dry matter (%)	Density (g cm^{-3})	Salinity (g NaCl dm^{-3})	Total form content (g kg^{-1} d.m.)						Available form content (mg dm^{-3})				
					N	P	K	Ca	Mg	S	$N\text{-}NO_3$	P	K	Ca	Mg
2005															
Peat	3.60	59.8	0.18	0.35	8.90	1.60	1.60	2.10	0.30	0.50	17.0	20.0	6.00	42.0	27.0
I	5.35	36.3	0.39	3.66	17.6	17.3	3.70	7.70	0.63	5.30	785	687	379	2265	500
II	5.80	38.1	0.39	1.69	16.6	13.0	2.20	6.70	0.56	4.70	346	671	224	2690	309
III	5.80	44.8	0.36	1.44	16.1	14.8	5.60	6.50	0.60	5.40	386	518	644	1596	285
IV	5.90	45.4	0.38	0.83	11.0	14.5	1.60	4.40	0.63	3.50	281	348	180	1625	202
2006															
Peat	3,50	58.8	0.20	0,35	9.30	1.60	0.50	2.47	0.14	0.17	16,5	19,0	5,0	40,0	27,0
I	5.40	36.8	0.28	3.36	11.4	6.95	5.05	2.12	1.75	1.90	330	810	845	3843	554
II	5.40	36.6	0.34	3.33	10.3	5.50	2.45	1.82	1.30	1.85	379	620	226	3272	413
III	5.40	22.2	0.30	2.10	9.90	4.10	4.90	1.70	1.20	1.75	223	574	703	2121	306
IV	5.90	24.6	0.38	2.64	9.00	3.90	2.65	1.70	1.30	1.71	228	449	295	3110	384

* Composition of substrates:
I – 50% compost I + 50% peat; II – 50% compost II + 50% peat; III – 50% compost III + 50% peat; IV – 50% compost IV + 50% peat;

other hand, was elevated in compost I. Moreover, the content of available nutrients, especially nitrogen, phosphorus and calcium, in some substrates exceeded the recommended limits. In 2006, elevated salinity was determined in compost I and II substrates, which were composed of 70% municipal sludge and 30% straw or sawdust (Table 1). Despite the added share peat, poor in nutrients, the excessive salinity found in the prepared mixtures was not mitigated. In most substrates, the nutrient content was higher than recommended.

In 2005, a significant impact of the substrate on the content of nitrogen, phosphorus, potassium and sulphur in leaves of *Impatiens* was recorded after 12 weeks of cultivation (Table 2). The highest level of total nitrogen was found in treatment II, where the compost included municipal sludge (70%) and sawdust compost (30%); the lowest level of total nitrogen was found in treatment III, with the compost variant containing sewage sludge (35%), potato pulp (35%) and sawdust (30%). The phosphorus content was the lowest in leaves of plants grown without any compost. The phosphorus content did not differ significantly between any of the pots containing municipal sludge compost. The highest level of potassium was found in treatment III, with compost containing sewage sludge (35%), potato pulp (35%) and straw (30%). This was due to the high content of potassium in the substrate (Table 1). The content of calcium (0.29-0.36%) and magnesium (0.077--0.079%) in leaves of *Impatiens* did not vary in any of the examined variants.

Table 2

Macronutrient composition of *Impatiens walleriana* leaves (% d.m.) at the end of the cultivation, depending on the substrates

Substrate*	2005					
	N_{total}	P	K	Ca	Mg	S
Control - peat	2.37 *bc***	0.69 *b*	1.79 *d*	0.33 *a*	0.078 *a*	0.20 *a*
I – compost I + peat	2.27 *cd*	0.99 *a*	2.17 *c*	0.29 *a*	0.078 *a*	0.18 *ab*
II – compost II + peat	2.58 *a*	0.99 *a*	2.24 *c*	0.36 *a*	0.079 *a*	0.13 *b*
III – compost III + peat	2.17 *d*	0.99 *a*	2.64 *a*	0.36 *a*	0.078 *a*	0.17 *ab*
IV– compost IV + peat	2.48 *ab*	1.01 *a*	2.42 *b*	0.34 *a*	0.077 *a*	0.19 *ab*
Mean	2.37	0.93	2.25	0.33	0.078	0.17
Substrate*	2006					
	N_{total}	P	K	Ca	Mg	S
Control - peat	1.06 *c*	0.79 *b*	0.98 *c*	0.89 *a*	0.086 *a*	0.11 *a*
I – compost I + peat	1.57 *a*	1.10 *a*	1.48 *a*	0.98 *a*	0.092 *a*	0.14 *a*
II – compost II + peat	1.53 *a*	1.14 *a*	1.49 *a*	0.99 *a*	0.093 *a*	0.18 *a*
III – compost III + peat	1.27 *b*	0.86 *b*	1.17 *b*	0.96 *a*	0.088 *a*	0.13 *a*
IV – compost IV + peat	1.31 *b*	0.83 *b*	1.18 *b*	0.96 *a*	0.088 *a*	0.14 *a*
Mean	1.34	0.94	1.26	0.96	0.090	0.14

* key: see Table 1

** figures designated same letters do not differ significantly

The sulphur content in leaves was the highest versus the control (0.20% S d.m.), but no significant differences in its content were recorded between variants I, III and IV.

In 2006 a significant impact of the substrates on the total nitrogen, phosphorus and potassium in leaves of *Impatiens* was recorded. Higher levels of total nitrogen were recorded in leaves of plants grown in substrates containing compost developed from sewage sludge (70%) and straw (30%) or sawdust (30%) than in substrates containing composts with potato pulp (variants II and IV). Higher levels of phosphorus and potassium were also recorded in leaves of plants from pots in the variants I and II than in the other pots. As regards the levels of calcium, magnesium and sulphur in plant leaves, no significant differences between the treatments were recorded.

According to KESSLER (2005), leaves of properly nourished *Impatiens walleriana* plants should contain N_{total} 3.6-5.8% d.m., P 0.8-0.9% d.m., K 1.4-2.4% d.m., Ca 1.8-2.4% d.m., Mg 0.9-3.6% d.m. and S 0.8-0.9% d.m. In both years of the present study, despite the high content of nutrients in the substrates and top dressing with compound fertilizer, the nitrogen content in leaves was lower (2.58-1.06% $N_{tot.}$ d.m.) than an optimal range for *Impatiens walleriana*. In the first year of our experiment, the phosphorus content in leaves of plants cultivated in the pots filled with composts (0.99-1.01% P d.m.) exceeded the recommended range of P 0.8-0.9% d.m. (KESSLER 2005). In the second year, the recommended range of phosphorus content in leaves appeared only in treatments I, II and IV. In both years, the content of potassium in leaves of *Impatiens walleriana* cultivated without any compost and in treatments I and II, were within the optimal range (1.4-2.4% K d.m.); in treatments III and IV (2.64 and 2.42% K d.m., respectively) it exceeded the recommended values. In both years, deficits of calcium, magnesium and sulphur in leaves of *Impatiens* occurred. The magnesium content was more than ten-fold less than recommended.

In 2005, it was only the phosphorus and potassium content in roots of *Impatiens* that varied depending on the substrates (Table 3). The phosphorus root content in treatments I, II, III and IV was significantly higher than in roots of plants grown without any compost (0.65% P d.m.). The highest amount of potassium (1.30% K d.m.) was recorded in roots of *Impatiens* grown in variant IV; there were no significant differences between the variants II and III.

During the second year, the substrates modified the level of total nitrogen, phosphorus, potassium and calcium in roots of *Impatiens*. The highest level of total nitrogen and phosphorus was recorded in roots of plants cultivated in treatments I and II, in which composts contained sewage sludge (70%) and straw (30%) or sawdust (30%). No significant differences in the total nitrogen content were recorded between roots of plants from the control and variant III, containing compost made from sewage sludge (35%), potato pulp (35%) and straw (30%). The highest level of potassium (0.40% K d.m.)

Table 3

Macronutrient composition of *Impatiens walleriana* roots (% d.m.) at the end of the cultivation, depending on the substrates

Substrate	2005					
	N_{total}	P	K	Ca	Mg	S
Control - peat	1.55 *a*	0.65 *b*	0.57 *c*	0.63 *a*	0.006 *a*	0.03 *a*
I – compost I + peat	1.56 *a*	0.80 *a*	0.79 *b*	0.61 *a*	0.008 *a*	0.05 *a*
II – compost II + peat	1.60 *a*	0.82 *a*	1.19 *a*	0.60 *a*	0.006 *a*	0.10 *a*
III – compost III + peat	1.52 *a*	0.77 *ab*	1.24 *a*	0.60 *a*	0.006 *a*	0.06 *a*
IV – compost IV + peat	1.53 *a*	0.84 *a*	1.30 *a*	0.62 *a*	0.008 *a*	0.08 *a*
Mean	1.55	0.78	1.01	0.61	0.007	0.06
Substrate	2006					
	N_{total}	P	K	Ca	Mg	S
Control - peat	0.95 *ab*	0.35 *b*	0.36 *ab*	0.59 *b*	0.007 *a*	0.04 *a*
I – compost I + peat	1.01 *a*	0.58 *a*	0.38 *ab*	1,16 *a*	0.008 *a*	0.08 *a*
II – compost II + peat	1.08 *a*	0.57 *a*	0.40 *a*	1.17 *a*	0.007 *a*	0.09 *a*
III – compost III + peat	0.90 *ab*	0.37 *b*	0.27 *bc*	1.17 *a*	0.010 *a*	0.05 *a*
IV – compost IV + peat	0.78 *b*	0.38 *b*	0.24 *c*	1.20 *a*	0.008 *a*	0.08 *a*
Mean	0.94	0.45	0.33	1.06	0.008	0.07

key: see Table 1
* figures designated same letters do not differ significantly

was found in roots of plants cultivated on substrate with compost II, which contained municipal sludge (70%) and sawdust (30%). The calcium content in roots of *Impatiens* did not differ significantly between the treatments containing composts, being the lowest in plants from the control pots.

No data can be found on the nutrient composition of roots of ornamental plants grown on substrates containing municipal sewage sludge compost. The information presented by Lis-Krzyścin (2006) proves that the content of total nitrogen, phosphorus, potassium, calcium and magnesium in roots of *Pelargonium × hortorum* L.H. Bailey is the highest in the active growth phase, afterwards decreasing until the end of the growing period. The total nitrogen content level in roots of *Impatiens* during the first year (0.77-0.84% P d.m.) was higher than in roots of *Pelargonium* fertilized with higher doses of nitrogen. Also, the phosphorus content in roots *Impatiens* in the first year of cultivation was higher than that of *Pelargonium* (0.41-0.22% P d.m.). This can be explained by a very high level of phosphorus content in the compost substrates (Table 1). The calcium content in roots of *Impatiens* cultivated on compost substrates was lower in the first year than in *Pelargonium* fertilized with nitrogen, but higher in the second year (1.16-1.20% Ca d.m.) than in roots of *Pelargonium* during the period of rapid growth (1.11% Ca d.m.).

During the first year of the cultivation, leaves of *Impatiens* accumulated 1.7-fold more total nitrogen and 1.8-fold more potassium than during the second year; the levels of phosphorus and sulphur were comparable, and those of calcium and magnesium were slightly lower. This was due to a higher content of available forms of N-NO_3, phosphorus, potassium and sulphur (Table 1) in the substrate during the first year. *Impatiens* showed signs of component deficits in leaves much later; top dressing was started after 7 weeks of cultivation (ZAWADZIŃSKA, DOBROWOLSKA 2009). In the second year, top dressing was introduced after the 4th week of cultivation. *Impatiens* develops ornamental flowers; it blooms especially profusely in summer months and can produce over 200 flowers during the growing season. In an experiment run by ZAWADZIŃSKA and DOBROWOLSKA (2009), *Impatiens* grown on substrates containing compost made from sewage sludge (70%) and straw (30%), added at 50% and 70% ratios, produced an average of 234 flowers. Abundant flowering in another experiment (data not included) resulted in a rapid depletion of nutrients from substrates. A similar response occurred in New Guinea Impatiens (*Impatiens hawkerii*) grown on substrates containing compost with the same ingredient composition (ZAWADZIŃSKA et al. 2009).

The current experiment proves that roots were more capable of accumulating calcium than other macronutrients. Calcium was the only trace element that was determined in higher concentrations in roots than in leaves of *Impatiens* in both years.

The key factor influencing the assimilation of nutrients is the ratio of ions in a substrate. During the nutrient absorption, potassium, calcium and magnesium act antagonistically. It is only when the substrate ensures Ca:K, Ca:Mg and K:Mg ratios optimal for a given species that the absorption of these elements can be efficient (LIS-KRZYŚCIN 2007, OSEMWOTA et al. 2007, FRANCKE 2010). Impaired magnesium absorption may result from a higher soil potassium content than recommended. Also, large doses of available potassium and ammonium nitrogen in the form of NH_4^+ inhibit magnesium absorption (MARSCHNER 1993). On the other hand, shortage of calcium in leaves is due to excess NH_4^+, K^+, Mg^{2+} and Na^{2+} ions in a substrate as well as high salinity (GERALDSON 1957). In an experiment conducted by ROMERO et al. (2007), excessive calcium fertilization decreased wet and dry weight of plants and reduced the potassium content in leaf cells. In our experiment, the substrates were rich in potassium, calcium and magnesium (Table 1), sometimes above the recommended levels. The antagonism between elements may have contributed to the poor absorption of calcium and magnesium from the substrates, leading to a deficit of these compounds in leaves of *Impatiens*.

CONCLUSIONS

1. The content of nitrogen, calcium, magnesium and sulphur in leaves of *Impatiens walleriana* grown on substrates containing municipal sludge compost, potato pulp and rye straw or coniferous tree sawdust was lower than the recommended optimal range for this species.

2. Impatiens cultivated on substrates with compost maturing for 7 months contained 1.70-fold more nitrogen and 1.8-fold more potassium in leaves; they had a similar phosphorus and sulphur content and but less calcium and magnesium than plants cultivated in the compost substrates after an 18-month ripening period.

3. Roots of *Impatiens walleriana* contained more calcium than leaves in both years of the experiment.

4. The nutrients supplied with the substrates and through top dressing fertilization were not sufficient to achieve the best cultivation results for *Impatiens walleriana*.

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