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VITROFOSMAK GLASSY FERTILIZER IN THE FERTILIZATION OF NURSERY-CULTIVATED YEW AND NINEBARK

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Abstract. The aim of the study was to evaluate the usefulness of glassy fertilizer as a slow-release fertilizer in container cultivation of *Taxus × media* and *Physocarpus opulifolius* in comparison with a common Osmocote Exact fertilizer used in nurseries. Glassy fertilizer granulated to Ø > 0.3 mm and Ø < 0.3 mm was applied in two doses: 3 and 6 $g \cdot dm^{-3}$. Macroelements, pH and EC were analysed for their content in the substrate. The total length of yew annual shoots was determined. Ninebark was measured for height and number of offshoots; it was also subject to quality classification. Osmocote Exact and coarsely-granulated glassy fertilizer showed systematic release of nutrients. The greatest length of annual shoots was marked on yews fertilized with Osmocote Exact and 3 g VitroFosMaK granulated to Ø < 0.3 mm per 1 dm^3 of the substrate. Ninebarks fertilized with glassy fertilizer granulated to Ø < 0.3 mm in the dose of 6 $g \cdot dm^{-3}$ of the substrate showed the greatest number of offshoots. The most valuable commercial material was obtained when the plants were fertilized with 6 g VitroFosMaK $\cdot dm^{-3}$ of the substrate.

Key words: glassy fertilizer, Osmocote Exact, *Taxus × media*, *Physocarpus opulifolius*

INTRODUCTION

Ornamental plant nurseries are a fast-evolving branch of horticulture. Significant progress has been observed in the area of container cultivation of plants which in Poland covers ca. 4393 ha and will probably increase as the demand for ornamental shrubs and trees in containers is widely growing. At present the production of plants in containers have reached the level of 100 million plants, of which coniferous trees and shrubs constitute the major part (30–35%) [Szydło 2006].

More intensified production requires better forms of its optimisation with a special focus on plant fertilization. Plants grown in containers are exposed to stress induced by improper watering and fertilization. The plants with smaller root masses are obviously

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prone to greater stress [Gonzalez and Cooperband 2002]. Since the roots develop only in the container, the quality of the substrate and proper fertilization are of key importance (adding from 40 to 60% to the cultivation success) [Chohura 2006, Murray et al. 1996]. In general, mineral fertilizers are characterised by high solubility in water. The pre-vegetation fertilization does not thus satisfy the plants' demand for nutrients, as only some part of elements is used effectively, while the majority of them are leached. Controlled-release fertilizers are commonly used in nursery gardening. The use of slow-release fertilizers with slower and prolonged release of nutrients ensures optimum provision of nutrients in the plants and can lead to a more homogenous granule distribution in the substrate, as well as to reduced leaching of nutrients [Girardi et al. 2005].

For the last few years Osmocote, a slow-release fertilizer aming at better fertilization and optimisation of plants' growth has widely been used in the majority of container cultivations in Poland. In 2000 a new generation of Osmocote Exact fertilizers, considered to be more oriented on the needs of given plant groups, was launched on the market [Nowoczesne nawożenie… 2006].

VitroFosMaK is a phosphorus-potassium fertilizer containing calcium and magnesium in the form of P_2O_5:K_2O:CaO:MgO – 12:10:14:22 (with microelements), developed at the Krakow University of Science and Technology [Stoch et al. 2003].

The aim of the present study was to estimate the effect of VitroFosMaK glassy fertilizer during yew and ninebark cultivation as compared to the common Osmocote Exact fertilizer.

MATERIAL AND METHODS

Two one-year studies on the effect of different doses and granulations of VitroFosMaK glassy fertilizer on yew and ninebark growth were carried out in private nurseries in southern Poland. The study was conducted on Hicksii yew *Taxus* × *media* Rehd. 'Hicksii' and Atlantic ninebark *Physocarpus opulifolius* (L.) Maxim.

The soil consisted of a mixture of peat substrate, deacidified with dolomite, and peat in a volumetric ratio of 1:3 (according to the recipe of the nursery owner). The experiment comprised five objects:

1. Fertilizing with Osmocote Exact hi-start (N:P_2O_5:K_2O:MgO – 15:10:10:3, 5–6 M) in the dose of 3 g·dm^{-3} of the substrate – for the ninebark; Fertilizing with Osmocote Exact standard (N: P_2O_5:K_2O:MgO –16:11:11:3, 3–4 M) in the dose of 3 g·dm^{-3} of the substrate – for the yew;
2. Fertilizing with VitroFosMaK granulated to Ø > 0.3 mm in the dose of 3 g·dm^{-3} of the substrate;
3. Fertilizing with VitroFosMaK granulated to Ø > 0.3 mm in the dose of 6 g·dm^{-3} of the substrate;
4. Fertilizing with VitroFosMaK granulated to Ø < 0.3 mm in the dose of 3 g·dm^{-3} of the substrate;
5. Fertilizing with VitroFosMaK granulated to Ø < 0.3 mm in the dose of 6 g·dm^{-3} of the substrate.

In the first decade of May, two year old plants were put into the 5 dm^3 pots. The type and doses of Osmocote fertilizer (the commonly used one) were determined by the nursery owner. The doses of VitroFosMaK: 3 and 6 $g \cdot dm^{-3}$ of the substrate were agreed on the basis of earlier studies on other ornamental plants. In the top-dressing fertilization, in the objects with glassy fertilizer, nitrogen was topped up three times using urea, according to the amount of the element introduced together with the Osmocote fertilizer. The last fertilization was performed at the end of June. The plants were watered adequately using sprinklers. The substrate analyses for the content of basic elements, pH as well as the EC were carried out twice [Sady et al. 1994]. During vegetation the plants were treated up to common procedures.

During vegetation period yew was measured twice (May and September) for the length of offshoots, which allowed to determine the total length of annual shoots per plant. During ninebark pruning in the second decade of July (as cutting off shoots increases the growth of a plant) the height and number of shoots were measured. The plants quality classification was also carried out. The appraisal was made by five people with emphasis on ninebark's decorative value (height, number of offshoots, shape and colour of leaves). The following marking scale was adopted: 1 – poor; 2 – sufficient; 3 – satisfactory; 4 – good; 5 – very good. After vegetation, the root system was also measured on the basis of quality classification (see above scale) of the ninebark root mass' size.

The experiments were established using the method of random subblocks in four replications, each replication consisting of 10 plants. The results were statistically evaluated by ANOVA and the means were separated by the Fischer's test at $p = 0.05$.

RESULTS AND DISCUSSION

The literature does not provide any information on nutritive requirements of different kinds of plants, including yew and ninebark. Aendekerk [after Chohura 2006] has specified 3 groups of plants characterised by little, medium and high nutritional needs. *Taxus* sp. was included into the first group of plants. However, Terpiński [1971] claims that yew (contrary to other coniferous plants) is a plant of high nutritional needs. None of the authors [Terpiński 1971, Chohura 2006] includes ninebark in their division of plants.

The substrate used for cultivation was analysed twice in the third decade of July and September (data included on the example of yew – tab. 1). PH and EC in the substrate increased together with the rise of the dose of glassy fertilizer and its finer granulation. The lowest pH of the substrate was determined when Osmocote Exact was used, whereas in the object fertilized with VitroFosMaK in the dose of 6 $g \cdot dm^{-3}$ and granulation below 0.3 mm the pH was the lowest. The smallest amount of salt was observed in the substrate fertilized with glassy fertilizer granulated to Ø > 0.3 mm and used in the dose of 3 $g \cdot dm^{-3}$, whereas the greatest salt concentration was noticed during Osmocote Exact fertilization. After heath cultivation, the substrate acidity decreased in the objects fertilized with glassy fertilizer in relation to the initial value, quite opposite to Osmocote fertilization [Lis-Krzyścin et al. 2004]. Lower substrate pH in these objects could have been caused by the relatively high content of calcium and magnesium in the glass. Higher salt concentration was noticed after using Osmocote rather than glassy fertilizer.

Table 1. Mineral components contents, pH and total salt concentration (EC) in the substrate during 1st year of yew cultivation
Tabela 1. Zawartość składników mineralnych w podłożu w uprawie cisa w pierwszym roku doświadczenia

	Objects Obiekty	Granulation Granulacja	pH	EC	$N\text{-}NH_4$	$N\text{-}NO_3$	N	P	K	Ca	Mg
				$mS \cdot cm^{-1}$	$mg \cdot dm^{-3}$						
Before cultivation Przed uprawą			4.12	0.78	112.0	145.5	257.5	258.39	170.66	1502.91	162.35
3rd decade of July 3. dekada lipca	Osmocote Exact		4.50	0.75	50.0	104.0	154.0	239.6	215.1	910.6	148.3
	V3*	Ø < 0.3 mm	4.96	0.30	31.5	26.0	57.5	89.5	79.8	933.7	233.3
	V6	Ø < 0.3 mm	5.24	0.38	56.0	43.5	99.5	186.3	135.7	1221.4	387.7
	V3	Ø > 0.3 mm	4.76	0.21	31.5	24.5	56.0	36.8	50.1	746.3	142.9
	V6	Ø > 0.3 mm	4.94	0.23	57.5	58.5	116.0	82.3	65.5	1025.0	200.0
3rd decade of September 3. dekada września	Osmocote Exact		4.75	0.79	52.5	19.3	71.8	109.2	102.1	774.2	84.9
	V3	Ø < 0.3 mm	5.08	0.22	15.8	10.5	26.3	105.8	34.9	899.0	160.7
	V6	Ø < 0.3 mm	5.64	0.24	17.5	21.0	38.5	111.7	62.8	973.7	248.1
	V3	Ø > 0.3 mm	5.14	0.15	21.0	15.8	36.8	97.0	42.0	764.4	143.2
	V6	Ø > 0.3 mm	5.35	0.23	26.3	21.0	47.3	105.4	59.1	875.8	211.8

* V3 – 3 g $VitroFosMaK \cdot dm^{-3}$, V6 – 6 g $VitroFosMaK \cdot dm^{-3}$

The results showing low content of mineral nitrogen in the substrate were due to conducting sample analysis in September, i.e. three months following the last nitrogen fertilization. The greatest nitrogen content was marked in the substrate fertilized with Osmocote, like in the study on heaths [Lis-Krzyścin et al. 2004]. The result has been obtained on the basis of gradual release of nitrogen from the fertilizer. Substrates which contained higher dose of glassy fertilizers were richer in mineral form of nitrogen.

The object fertilized with glassy fertilizer showed lower contents of phosphorus and higher contents of magnesium, as in geranium and heath cultivation [Lis-Krzyścin et al. 2004, Lis-Krzyścin and Wacławska 2005]. The lower phosphorus content was probably due to the slower rate of releasing nutrients from glassy structures and to the amount of elements taken by the plants. In laboratory conditions the release of phosphorus from glassy fertilizers comes prior to the release of magnesium [Wacławska et al. 2001]. In the present study the content of calcium in the substrate fertilized with glassy fertilizer was generally higher than after the use of Osmocote, contrary to the experiments on heath [Lis-Krzyścin et al. 2004]. When fertilizing with VitroFosMaK, glass in higher dose and granulation below 0.3 mm triggered higher contents of potassium, calcium and magnesium in the substrate.

At ninebark fertilization with glassy fertilizer, tendencies in the contents of mineral elements in the substrate (data not included) were similar to the case of yew cultivation. The contents of elements determined were slightly reduced, which might have been effected by greater uptake of elements due to lower substrate pH and more intensive growth of the plants after pruning. The effect of VitroFosMaK on substrate pH and total salt concentration was also comparable during yew cultivation.

The analysis of the effect of fertilization showed that the dose and granulation of VitroFosMaK had an impact on the total length of yew annual shoots (tab. 2). Lower dose of coarsely-granulated glass seemed to have a better effect. The longest shoots were noticed at the plants fertilized with Osmocote Exact and with 3 g glassy fertilizer granulated to Ø > 0.3 mm per 1 dm^3 of the substrate. The smallest length of shoots was observed with plants fertilized with glass granulated to Ø < 0.3 mm, and used in the dose of 6 $g{\cdot}dm^{-3}$ of the substrate.

Table 2. The effect of fertilization on total length of yew annual shoots (cm)
Tabela 2. Wpływ nawożenia na sumę przyrostów (cm) cisa

Fertilization Nawożenie	1st year of study 1. rok badań			2nd year of study 2. rok badań		
	Ø > 0.3 mm	Ø < 0.3 mm	LSD_{granul} NIR_{granul}	Ø > 0.3 mm	Ø < 0.3 mm	LSD_{granul} NIR_{granul}
Osmocote Exact	73.69			81.29		
V 3*	72.44	52.00	6.089	87.29	69.08	2.533
V 6	59.13	37.48		79.49	67.23	
LSD_{dose} NIR_{dawka}	7.457		10.546	2.068		3.583

* V3 – 3 g VitroFosMaK·dm^{-3}, V6 – 6 g VitroFosMaK·dm^{-3}

It seems that relatively fast release of mineral elements from glassy fertilizer granulated to Ø < 0.3 mm and used in the dose of 6 $g{\cdot}dm^{-3}$ of the substrate resulted in the too high content of mineral components in the substrate, which affected negatively the length of yew shoots.

Kolasiński [2006] reports that the fertilizer doses of 2.5 to 5 g per 1 dm^{-3} of the substrate, which are intended to be used for 5 to 6 months for slow-growing coniferous, can be treated as correct, provided that they are used at an early stage. *Thuja plicata* which received Osmocote plus (16N-8P-12K + 2MgO) at 3, 4 or 5 $g{\cdot}dm^{-3}$ of the substrate showed increase in average shoot length, yet at no significant difference between application rates; there were not any differences in the plant growth or quality, either. With *Juniperus media*, however, the percentages of plants in the higher size grade (40/50 cm) were markedly increased by the higher application rates [Degeyter 1998]. For younger pine trees lower fertilizer doses are recommended. The study on the influence of slow-release fertilizers on the growth of *Juniperus scopulorum* revealed that in the 1st year of container cultivation the dose recommended by the producer was satisfactory, whereas in the 2nd year it was too high, which indicates that fertilizer type and doses should be selected individually according to genus, kind and age of the plant [Kolasiński 2006]. However Rietze and Siedel [1995] found out that the growth of *Taxus baccata* was influenced more by container size, and thus water supply, than by fertilizer (the commercial slow-release product Plantacote Depot 8 M).

In July, before ninebark pruning, the height of the plants was measured (tab. 3). In the first year the greatest height was noticed at the plants fertilized with Osmocote Exact. However, the stature of these plants was poorer, which was also reflected in the lower weight of shoots that had been cut (data not included). Introduction of glassy fertilizer into the substrate resulted in the decrease in ninebark's height. The plants fertilized with 3 g of VitroFosMaK granulated to Ø < 0.3 mm per 1 dm^3 of the substrate were the lowest. In the 2nd year of cultivation no differences of any statistical significance were observed in the height of ninebarks coming from the objects fertilized with Osmocote Exact and 6 g VitroFosMaK·dm^{-3}, irrespective of granulation. The plants in the object with a higher dose of glassy fertilizer used (data not included) showed greater weight of the cut shoots.

Table 3. The effect of fertilization on ninebark's height (cm)
Tabela 3. Wpływ nawożenia na wysokość (cm) pęcherznicy

Fertilization Nawożenie	1st year of study 1. rok badań			2nd year of study 2. rok badań		
	Ø > 0.3 mm	Ø < 0.3 mm	LSD_{granul} NIR_{granul}	Ø > 0.3 mm	Ø < 0.3 mm	LSD_{granul} NIR_{granul}
Osmocote Exact	101.08			130.15		
V 3*	76.77	70.40	2.009	122.55	120.58	ns
V 6	88.45	78.02		129.60	127.10	
LSD_{dose} NIR_{dawka}	1.640		2.841	2.747		3.885

* V3 – 3 g VitroFosMaK·dm^{-3}, V6 – 6 g VitroFosMaK·dm^{-3}

The greater number of shoots has been observed on ninebarks fertilized with coarsely granulated (Ø > 0.3 mm) glassy fertilizer used in the dose of 6 g·dm^{-3} of the substrate (tab. 4). The number of shoots was four times smaller on the plants in the object where Osmocote Exact was used, and it counted as the smallest number of shoots among all objects. Higher dose of VitroFosMaK fertilizer as well as greater granules diameter triggered an increase in the number of offshoots.

Table 4. The effect of fertilization on average number of ninebark offshoots (per plant)
Tabela 4. Wpływ nawożenia na średnią liczbę pędów (szt./roślinę) pęcherznicy

Fertilization Nawożenie	Number of shoots – Liczba pędów		
	Ø > 0.3 mm	Ø < 0.3 mm	LSD_{granul} NIR_{granul}
Osmocote Exact	5.65		
V 3*	14.17	12.42	0.908
V 6	21.07	15.02	
LSD_{dose} – NIR_{dawka}	0.741		1.284

* V3 – 3 g VitroFosMaK·dm^{-3}, V6 – 6 g VitroFosMaK·dm^{-3}

It seems that constant and uniform nutrition of ninebark (regular release of elements and their limited leaching) allowed to obtain plants of greater height (fertilized with Osmocote Exact) or greater number of shoots (fertilized with glassy fertilizer in a dose of 6 g·dm^{-3} of the substrate). Summer pruning of ninebarks, aimed at enhancing their growth, resulted in a greater demand for nutrients on their part. Unfavourable effect of the higher dose of glassy fertilizer on yew growth has not been observed. Heaths fertilized with glassy fertilizer in the dose of 4 g·dm^{-3} of the substrate grew better (as far as height and diameter of the aboveground part of the plants are concerned) than the plants treated with Osmocote Plus [Lis-Krzyścin et al. 2004].

The quality classification of the aboveground part of the plants revealed the greatest decorative value in the ninebarks fertilized with VitroFosMaK in the dose of 6 g·dm^{-3}, irrespective of granulation (tab. 5). The plants fertilized with Osmocote Exact received the lowest mark for being too high and unbranched.

Table 5. Quality classification of ninebark decorative value and roots mass size on the 1–5 scale
Tabela 5. Ocena bonitacyjna dekoracyjności roślin i przerośnięcia bryły korzeniowej pęcherznicy w skali 1–5

Fertilization Nawożenie	Decorative value Dekoracyjność roślin		Roots mass size Przerośnięcie bryły	
	Ø > 0.3 mm	Ø < 0.3 mm	Ø > 0.3 mm	Ø < 0.3 mm
Osmocote Exact	1		3	
V3*	4	4	4	4
V6	5	5	5	5

* V3 – 3 g VitroFosMaK·dm^{-3}, V6 – 6 g VitroFosMaK·dm^{-3}

The type of fertilization influenced the growth of root mass (tab. 5). When used in a higher dose, glassy fertilizer had a positive effect on root mass, significantly increasing its size. The root system of the plants fertilized with Osmocote Exact was the least developed. However, heaths fertilized with glassy fertilizer and Osmocote fertilizer were qualified as having the best decorative value and greatest size of root mass [Lis-Krzyścin et al. 2004].

CONCLUSIONS

1. The total length of yew annual shoots was marked at yews fertilized with Osmocote Exact and 3 g VitroFosMaK granulated to Ø > 0.3 mm and per 1 dm^3 of the substrate, enriched with nitrogen.
2. Ninebarks fertilized with glassy fertilizer granulated to Ø > 0.3 mm in the dose of 6 g·dm^{-3} of the substrate together with nitrogen showed the greatest number of offshoots.
3. The most valuable commercial material of *Physocarpus opulifolius* was obtained when the plants were fertilized with 6 g VitroFosMaK·dm^{-3} of the substrate and nitrogen.

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NAWOŻENIE SZKŁEM NAWOZOWYM VITROFOSMAK CISA I PĘCHERZNICY UPRAWIANYCH W SZKÓŁCE

Streszczenie. Podjęte badania dotyczyły nawożenia roślin ozdobnych w uprawie pojemnikowej. Celem pracy była ocena przydatności szkła nawozowego jako nawozu o spowolnionym działaniu w uprawie pojemnikowej cisa pośredniego *Taxus* × *media* i pęcherznicy kalinolistnej *Physocarpus opulifolius* w porównaniu z powszechnie stosowanym w szkółkarstwie nawozem Osmocote Exact. Wprowadzono szkło o granulacji poniżej 0,3 mm i powyżej 0,3 mm w dwóch dawkach 3 i 6 $g \cdot dm^{-3}$. Oznaczono w podłożu zawartość makroskładników, pH, EC. U cisa określono sumę jednorocznych przyrostów. Natomiast u pęcherznicy wykonano pomiar wysokości, liczby pędów bocznych oraz ocenę bonitacyjną. Stwierdzono systematyczne uwalnianie składników pokarmowych z Osmocotu Exact i szkła nawozowego o grubszej granulacji. Największą sumą jednorocznych przyrostów charakteryzowały się cisy nawożone Osmocote Exact i 3 g VitroFosMaKu o granulacji powyżej 0,3 mm na 1 dm^3 podłoża. Najwięcej pędów bocznych wytworzyły pęcherznice nawożone szkłem nawozowym o granulacji powyżej 0,3 mm w dawce 6 $g \cdot dm^{-3}$ podłoża. Najbardziej wartościowy materiał handlowy uzyskano nawożąc rośliny 6 g $VitroFosMaKu \cdot dm^{-3}$ podłoża.

Słowa kluczowe: szkło nawozowe, Osmocote Exact, *Taxus* × *media*, *Physocarpus opulifolius*

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