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SLOW – RELEASE FERTILIZERS AND POSSIBILITIES OF THEIR UTILIZING IN NURSERY

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Abstract

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Reserve, slow-release fertilizers (SRF) enable to simplify the whole system of plant nutrition and fertilisation. Tabletted fertilizers of the Silvamix series represent a prospective product of Czech provenience. At our university, these fertilizers have been tested and used since the year 1991. Ornamental woody species grown in containers were investigated in two stages. Experiments with ornamental plants were established using one-year-old cuttings and seedlings of the following deciduous and evergreen woody species: *Cotoneaster dammeri Skogholm, Berberis thunbergii, Potentilla fruticosa Snowflake, Ligustrum vulgare Atrovirens* and *Picea omorika*. After planting into containers, fertilizers in the dose of 1 tablet (i.e. 10 g) per litre of substrate were applied either to roots level or on the soil surface in the container. Silvamix in the dose of 5 $g.l^{-1}$ was used as the tested fertilizer in the second stage. It was applied during the planting in the form of tablets and/or a powder. Control plants were fertilized in the course of growing season using a common agricultural fertilizer Cererit Z. The annual plants increments were measured. These experiments demonstrated a long-term optimum effect of this product on woody species and an equal quality and efficiency of its tabletted and powdered forms.

fertilizers, nursery production, growing technologies, ornamental plants

Reserve, slow-release fertilizers (SRF) enable to simplify the whole system of plant nutrition and fertilisation. The period of efficiency is dependent on the type and dose of fertilizer, soil properties and climatic conditions. There are two basic issues concerning basic and supplemental fertilization of forest stands. The first one concerns nutrition of nursery seedlings in and/or outside containers while the second one stock fertilization of seedlings after their replantation to target locality and supplemental fertilizing of young trees (Kučera, 1995). A lot of various types of stock fertilizers with an extended period of efficiency have been developed for this purpose. The slow and gradual release of nutrients from these special fertilisers is accomplished by different mechanisms, which also cause different results.

Perhaps the best known of them is the pelleted fertilizer Osmocote which is used throughout Europe, first of all in ornamental plant nurseries. Application of such fertilizers seems to be important especially in the field of establishment of permanent stands because it provides a continuous supply of nutrients to plants throughout the most critical period of their existence, i.e. after replanting, during the period of rooting and in the first stage of their growth and development. This critical period may last either for several months (e.g. for herbs) or even for several years (in case of woody species) and depends above all on climatic factors occurring in the given period of time. It is also obvious that after their replantation in the target locality it is mostly impossible to provide the plants with a similar care as in the period of pre-planting.

The slow-release fertilizers can be divided into two basic groups: fertilisers with low water solubi-

lity, which release the nutrients by gradual dissolving (this function of these fertilizers is based on the principle of low-soluble salts) and watersoluble fertilisers that are coated or encapsulated by various substances, which slow down the process of dissolution. Šrámek, Dubský (2000) defined this group as "fertilisers with controlled release of nutrients." In the past thirty years, many types of such fertilisers have appeared on our market, for example the following brands: Preform, Silvamix, Ferilinz, Dukofert, Nutricote, Osmocote, Plantacote, Strom – Konifer, Strom – Folixil.

Other brands were tested abroad only. The experimental testing was carried out by numerous professionals working in the field of landscape gardening and forestry. The expert literature describes the results, which vary substantially due to the type of the fertiliser used, dosage and the way of use, e.g. Gysi (1992), Keever, Cobb (1990), Chmara (1991), Soukup, Matouš (1979), Nagy, Švihorík (1988), Nárovec, Štěnička (1991), Waradzin (1988), Witt, Kruger (1989), Laiche (1991), Sanftleben (1994), Vavříček (2000), Dubský, Kubíček (1999). This research has proved that the speed of the nutrient release is the limiting factor in all the tested fertilizers, especially the release of nitrogen (or potassium in some cases). Massive and fast release of easily soluble compounds, which are inappropriately incorporated in this type of fertilisers (e.g. urea, potassium sulphate, superphosphate), can be the cause of disorder in plant nutrition, as well as direct damage to the plants. Such situation was described for instance in the case of the Preform fertilizer (Nárovec, Jurásek, 2000).

For ornamental plants, currently the most frequently used type features the fertilizers with controlled release of nutrients, which follow the vegetation cycle of the plants (direct proportion to the course of the plant vegetation curve). The Silvamix brand fertilizers show a very good fixation of nutrients, which is the necessary precondition of their successful use in the nursery production. In our country, these fertilizers have been tested with very good results for example by Kubíček, Hegner (1991), Fišer (1990), Kučera (1995), Klocek (1995), Salaš, Řezníček, Čáp (2000), Walendzik (1996). Tabletted, long-term soluble fertilizers of the Silvamix series represent a prospective product of Czech provenience. At our university, these fertilizers have been tested and used since the year 1991 (Salaš, Řezníček, 2000).

MATERIAL AND METHODS

Ornamental woody species grown in containers were investigated in two stages. It can be said that plants grown in this way are more susceptible to fluctuations of major environmental factors (i.e. temperature, irrigation and nutrition) than those cultivated on seed beds. However, the obtained results were very favourable regardless to this fact. During the first stage of our experiments, long-term dressing effects of Silvamix Forte (N – 17,5%; P_2O_5 – 17,5%; K_20 – 10,5%; MgO – 9,0%) and Silvamix Mg (N – 8,0%; P_2O_5 – 12,0%; K_20 – 5,0%; MgO – 15,0%) fertilizers were tested using ornamental woody species mentioned below (Kubíček, Hegner, 1991). Standard cultivation substrate was used in the experiments, which is available under the commercial name "Horticultural substrate B". The characterisation of this substrate is stated in the table below.

I: *Parameters of the Horticultural substrate B*

Water content (%)	45 – 65
Organic substances in dry matter (%)	> 75
Content of N in dry matter (%)	0,08 – 0,14
Content of P in dry matter (%)	0,04 – 0,05
Content of K in dry matter (%)	0,09 – 0,21
Content of water-soluble salts (%)	0,35
pH in water	5,0 – 6,5

Experiments with ornamental plants were established using one-year-old cuttings and seedlings of the following deciduous and evergreen woody species: Cotoneaster dammeri Skogholm, *Potentilla fruticosa* Snowflake (cuttings) and *Berberis thunbergii* (seedlings). After planting into containers (volume of 1 litre), fertilizers in the dose of 1 tablet (i.e. 10 g) per litre of substrate were applied either to roots level or on the soil surface in the container. Control plants were fertilized in the course of growing season using a common agricultural fertilizer Cererit Z (N – 10,0%; P_2O_5 – 9,0%; K_20 – 14,0%; MgO – 1,3% (in the dose 7 g per litre). For the purpose of this experiment, the Cererit brand was used as a control fertilizer. This fertilizer is still widely used in our nurseries. The experiment featured two types of fertilizer from the Silvamix range, due to their optimum composition for woody plants (Silvamix Forte), and higher content

of potassium (Silvamix Mg). The expected effect period of the Silvamix fertilisers is two vegetation periods (unlike the Cererit fertilizer). The Silvamix fertilizers were applied in a single dose during the planting, while the Cererit fertilizer was applied in half amounts in April and July.

Experimental plants were grown in containers placed on a black plastic foil (30 plants each in three replicates, i.e. 90 plants in each variant). For irrigation, a classical irrigation system was used. Experiments were carried out within the framework of a routine operation of ornamental nursery in the course of two growing seasons. A random checking carried out to the end of the third year of cultivation revealed well visible remnants of disintegrated tablets in the substrate.

after the application of fertilizers in any variant of the experiment. The experiments took place within the normal operation of the ornamental nursery, the plants were watered as required (by large-scale irrigation system with PUK type sprinklers in the first phase, and with the NAMIR – NADIR micro-irrigation system in the second phase).

The following basic growth parameters were measured in the experimental plants: plant height (first year), plant height (total), number of shoots, length of the terminal increment (*Picea omorika*). The evaluation of the root system was carried out in a non-destructive way in most of the plants, which means the substrate was washed out from the roots of the woody plants and the roots were assessed visually. The destructive method was used in the case of the *Ligus-*

II: *Experimental variants*

First stage - *Cotoneaster dammeri* Skogholm, *Berberis thunbergii, Potentilla fruticosa* Snowflake	
Variant:	Silvamix Mg, surface application
	Silvamix Mg, application to the roots level
	Silvamix Forte, application to the roots level
	Control – Cererit Z
Second stage - *Ligustrum vulgare* Atrovirens, *Picea omorika*	
Variant:	Silvamix Forte – tablets
	Silvamix Forte – powder
	Cererit Z – control

In the second stage of our experiments with Silvamix fertilizers, attention was paid to testing of their effects on other genera of woody plants on the one hand and to the evaluation of efficiency of their application in the form of powder. This was done due to requirements of horticultural practice because it was not always possible to apply tablets under conditions of normal operation. Depending on the equipment, a powder can be mixed with the substrate before planting and the possibility of its application as top dressing is also rather interesting.

For these experiments plants grown in containers were used. Seedlings were planted into containers and placed on a shaded area 30 plants each (in three replicates, i.e. 90 plants in each variant). Silvamix Forte in the dose of 5 $g.l^{-1}$ was used as the tested fertilizer. It was applied during the planting in the form of tablets and/or a powder. For experiments, both rooted cuttings of *Ligustrum vulgare* Atrovirens and seedlings of *Picea omorika* were used. In the course of growing season, both controls and experimental plants were routinely treated and irrigated. In controls, Cererit Z was again used for the fertilization (in the dose 5 g per litre). No phytotoxic damage of plants was observed

trum and *Picea* species. The roots of selected plants were cleared of the substrate (by washing out), dried at the temperature of 105° C and weighed. The results are stated in Table XI. – XII. (Weight of dried roots). Results of growth parameters of trees and shrubs were statistically analysed on Microsoft Excel.

RESULTS AND DISCUSSION

Growth parameters of trees and shrubs are given in Table III. – X. The evaluation of results of our two-year experiments revealed that after the application of Silvamix fertilizers the annual increments of experimental plants were statistically different. In the first year, these annual increments were significantly higher in all cases than those recorded in the following year. Although in the second year the annual increments were slightly lower, it was possible to demonstrate a generally very positive effect of applied fertilizers on the long-term growth of container cultures. It is also necessary to remember that control plants were fertilized with Cererit Z repeatedly in both years of the experiment while the experimental ones only once, i.e. after re-planting into containers. However, as compared with repeatedly applied

agricultural fertilizer Cererit Z with rapidly released nutrients, the expected bi-annual effect of Silvamix fertilizers could be demonstrated very easily and the overall increase ranged, in dependence on plant species, chemical composition of fertilizers, their texture and method of application, from 10 to 75%. This means that the efficiency of fertilizers releasing nutrients slowly was significantly better in woody species growing for several seasons than that of common, rapidly soluble products and that the optimum results could be obtained by means of a proper selection of nutrient composition of fertilizer (i.e. Silvamix Forte, Silvamix Mg), method of application (i.e. on the soil surface, to roots level or into the substrate) and texture (i.e. in the form of a powder or in tablets). This can be seen in Table VI. – X.

When growing ornamental plants in containers it is always necessary to adapt both the amount and the form of supplied nutrients to plant requirements and to physical properties of substrates used under conditions of intensive daily irrigation. It can be said that from this point of view the obtained results are very valuable and that they will be definitely appreciated by every experienced nurseryman.

When analyzing all stress factors influencing the growth of plants cultivated in containers it is possible to expect that, with regard to results of an analysis of overall bi-annual increments of wood species mentioned above, their cultivation on seed beds should give undoubtedly better results and that the effect of Silvamix fertilizers on these plants would be even better than in our experiments. Besides, these experiments also corroborated our earlier observations that when growing plants in containers, i.e. outside the seed beds, it is appropriate to think about a supplementary dressing of woody species in the spring season of the second year (i.e. after the application of tablets) with fertilizers containing easily available nitrogen; however, it is necessary to take into account climatic conditions of the first year of growing (i.e. precipitation and temperatures), irrigation intensity (because of danger of substrate elution) and nutritional requirements of plants. This recommendation concerns above all ornamental woody species with higher nutritional requirements.

A very good development of roots of experimental plants dressed with Silvamix fertilizers represents a significant advantage because it is important for their subsequent growth and development on the target site. In case of application of tabletted fertilizers it was also possible to demonstrate a significant role of chemotropism of plants in the mechanism of their nutrition, i.e. the capacity to change the direction of root growth in dependence on the chemical composition of soil. In practice this means that new roots encircle the tablet with a dense network of hairy roots and thus create good predispositions for the maximum utilization of nutrients. When using tablets, the osmotic values of soil substrate are several times lower than in case of application of the same dose of complex, water-soluble and chloride-free fertilizers so that it is possible to apply them even to more sensitive plants.

The data presented above also indicate that a targeted, focal application of tabletted Silvamix fertilizers can result in a cost reduction in the course of growing season. When using soluble mineral fertilizers, the basic (i.e. stock) dose is mixed with substrate at the moment of planting and the necessary nutrients are replenished by means of supplementary dressing in the course of growing season. However, these stock and slowly soluble fertilizers enable to simplify the system of plant nutrition. Their application ensures a better use of nutrients, their lower losses due to retrogradation and, especially, wash-off into groundwater, and, last but not least, better economic results. Until now, a practical experience with application of fertilizers in ornamental and forest nurseries indicates that an undoubtedly high quality of these products is further increased due to a possibility to apply them as top dressing but without any danger of leaf burning (in nurseries, a supplementary dressing of young plants with solid fertilizers belongs to the most demanding working operations especially because of an acute danger of burning of plants). This was completely proved during the second stage of our experiments.

Results of one-year experiments presented in Table VI. – X. Experiments were established in spring and evaluated after the end of growing season. Methodology and sites of all experiments were identical in both years and the treatment as well. As shown in Table VI. – X. the second stage corroborated results obtained earlier. For our practice, the most important observation represents the fact that fertilizers of the Silvamix product line can be applied in different forms (i.e. as tablets or in the form of a powder) without any differences in their efficiency. Their application in the powdered form provides new possibilities of supplementary dressing not only in nurseries but also on permanent sites. From the economic point of view, such an application is advantageous in case of their extensive application (i.e. as supplementary dressing of bare land, in closed stands and as admixtures into growing substrates) while tablets enable the maximum economy in case of individual application (provided that the principles of dressing are observed and that all workers are fully responsible and reliable and that they respect recommended doses and methods). The possibility of application of powdered form using spreading machines without any greater danger of chemical damage of aboveground parts of plants represents another enumerable advantage of this method.

III: *Average annual increment – Cotoneaster dammeri Skogholm*

Growing season	Silvamix Mg, surface application		Silvamix Mg, application to the roots level		Silvamix Forte, application to the roots level		Control Cererit Z	
	mm	%	mm	%	mm	%	mm	%
1	178	172,8	219	212,6	176	170,9	103	100,0
2	227	89,7	216	85,4	160	63,2	253	100,0
1 + 2	405	113,1	435	121,5	336	93,9	358	100,0
#Total	**		**		–		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

IV: *Average annual increment – Berberis thunbergii*

Growing season	Silvamix Mg, surface application		Silvamix Mg, application to the roots level		Silvamix Forte, application to the roots level		Control Cererit Z	
	mm	%	mm	%	mm	%	mm	%
1	490	242,6	362	179,2	255	126,2	202	100,0
2	159	93,5	188	110,6	157	92,4	170	100,0
1 + 2	649	174,5	550	147,9	412	110,8	372	100,0
#Total	**		**		**		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

V: *Average annual increment – Potentilla fruticosa Snowflake*

Growing season	Silvamix Mg, surface application		Silvamix Mg, application to the roots level		Silvamix Forte, application to the roots level		Control Cererit Z	
	mm	%	mm	%	mm	%	mm	%
1	245	140,8	24,4	140,2	218	125,3	174	100,0
2	120	85,1	14,9	105,7	166	117,7	141	100,0
1 + 2	365	115,9	39,3	124,8	384	121,9	315	100,0
#Total	**		**		**		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

VI: *The average height of plants – Ligustrum vulgare Atrovirens*

Growing season	Silvamix Forte – tablets		Silvamix Forte – powder		Control – Cererit Z	
	mm	%	mm	%	mm	%
1	192,7	162,6	175,8	148,4	118,5	100,0
2	279,7	207,5	243,3	180,5	134,8	100,0
1 + 2	472,4	186,5	419,1	165,5	253,3	100,0
#Total	**		**		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

VII: *The average number of lateral annual shoots – Ligustrum vulgare Atrovirens*

Growing season	Silvamix Forte – tablets		Silvamix Forte – powder		Control – Cererit Z	
	nb	%	nb	%	nb	%
1	7,1	110,9	6,6	103,1	6,4	100,0
2	6,3	103,3	5,6	91,8	6,1	100,0
1 + 2	13,4	107,2	12,2	97,6	12,5	100,0
#Total	**		–		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

VIII: *The average increments in the course of growing season – Ligustrum vulgare Atrovirens*

Growing season	Silvamix Forte – tablets		Silvamix Forte – powder		Control – Cererit Z	
	mm	%	mm	%	mm	%
1	508,6	186,0	470,9	172,2	273,5	100,0
2	807,5	269,2	624,4	208,1	300,0	100,0
1 + 2	1 316,1	229,5	1 095,3	191,0	573,5	100,0
#Total	**		**		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

IX: *Average height of plants – Picea omorika*

Growing season	Silvamix Forte – tablets		Silvamix Forte – powder		Control – Cererit Z	
	mm	%	mm	%	mm	%
1	140,6	105,3	142,5	106,7	133,5	100,0
2	223,0	91,2	231,1	94,6	244,4	100,0
1 + 2	363,6	96,2	373,6	98,9	377,9	100,0
#Total	–		–		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

X: *Average length of the terminal increment – Picea omorika*

Growing season	Silvamix Forte – tablets		Silvamix Forte – powder		Control – Cererit Z	
	mm	%	mm	%	mm	%
1	35,0	106,1	37,5	113,6	33,0	100,0
2	34,8	107,7	31,2	96,6	32,3	100,0
1 + 2	69,8	106,9	68,7	105,2	65,3	100,0
#Total	*		–		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,05 significance level
- Not confirmative difference

XI: *Weight of dried roots – Ligustrum vulgare Atrovirens*

	Silvamix Forte – tablets		Silvamix Forte – powder		Control – Cererit Z	
	g	%	g	%	g	%
	11,2	210,1	9,9	185,7	5,3	100,0
#Total	**		**		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

XII: *Weight of dried roots – Picea omorika*

	Silvamix Forte – tablets		Silvamix Forte – powder		Control – Cererit Z	
	g	%	g	%	g	%
	8,5	163,1	6,7	128,1	5,2	100,0
#Total	**		**		–	

Notes:
Statistical analysis (total)
** Highly confirmative difference on 0,01 significance level
- Not confirmative difference

CONCLUSIONS

Partial information gained from the experiments with the Silvamix fertilizers was continuously published in several articles. This fact enables us to summarise the results of the experiment and to generalise them. A general evaluation of our experiments showed that the fertilizer Silvamix Forte was comparable with the top foreign products. However, its price is much more acceptable. These experiments demonstrated a long-term optimum effect of this product on woody species and an equal quality and efficiency of its tabletted and powdered forms. When comparing the effects of its application on the soil surface and into the substrate no marked differences were found out. The method of application is dependent on the technology used and needs of the user.

No phytotoxic damage of experimental woody species was observed immediately after the application of fertilizers or in the course of our experiments. Basing on our experience with the application of other tabletted fertilizers it is possible to conclude that these fertilizers show a very well solved binding of individual elements combined with their gradual release into the substrate; this is important above all in case of nitrogen because there is a danger of „burning“ of roots due to their direct contact with fertilizer or due to its rapid release as well as a danger of overdosage with nitrogen within the first year after its application (because of a bad ripening of wood and a subsequent damage during the winter season) and/or due to a nitrogen deficiency caused by wash-off of nutrients in the year to follow. An optimum plant nutrition, as ensured by Silvamix fertilizers in combination with substances affecting positively the water regime in soil or in substrate (e.g. by hydroabsorbents Terra-Cottem, Salaš, Řezníček, 2000) can help to a more rational use of applied fertilizers by woody species. Nevertheless, it is recommended to pay attention to a preventive additional dressing with an easily available form of nitrogen at the beginning of the second year of cultivation, especially for species with higher requirements of nutrients, in case of cultivation of woody species under conditions of their growing outside the seed bed (i.e. intensive irrigation, very permeably substrate, frequent stress situations due to fluctuations of abiotic factors).

Within the period of seven-year experiments, an overall positive effect of applied fertilizers on the development of plants under study was demonstrated. They showed a positive effect on the dynamics of growth annual shoots. In spite of a more intensive growth of annual shoots no greater damage of plants than in control was recorded due to a bad ripening of annual shoots. Experimental plants were more resistant to stress conditions, especially to fluctuation of temperature and humidity. As compared with controls, lower loses in the course of cultivation were recorded and the root system was denser, of better quality and with a better degree of rooting. This is a very important observation because such plants are more predisposed to overcome the shock caused by replanting to the permanent site and they are a warranty of good rooting and growth.

SOUHRN

Hnojiva s pozvolným uvolňováním a možnosti jejich využití ve školkařství

Experimenty byly založeny u řízkovanců a semenáčků rodů Cotoneaster dammeri Skogholm, Berberis thunbergii, Potentilla fruticosa Snowflake, Ligustrum vulgare Atrovirens, Picea omorika. Pokusné rostliny byly vysazeny do kontejnerů o objemu jeden litr a umístěny ve stínovišti. V experimentech byla využita hnojiva Silvamix Forte, Silvamix Mg, Cererit Z (kontrola) ve formě tablet, granulí či drti. Aplikace byla provedena na povrch a do pěstebního substrátu. Po aplikaci hnojiv nebylo u rostlin v žádném z experimentů zjištěno fytotoxické poškození. Při celkovém hodnocení vykonaných experimentů se potvrdil předpoklad rovnocennosti použití jak tabletované, tak i sypké formy hnojiva Silvamix. Byl zjištěn celkový pozitivní vliv na vývoj sledovaných rostlin. Aplikovaná hnojiva Silvamix kladně ovlivnila dynamiku růstu letorostů. Sledované rostliny lépe odolávaly stresovým podmínkám, zejména teplotním a vlhkostním výkyvům. Byly zaznamenány menší ztráty v průběhu pěstování. Kořenová soustava byla hustší, kvalitnější, rostliny vykazovaly vyšší stupeň prokořenění. Bylo zjištěno, že hnojiva Silvamix mají velmi dobře vyřešenou vazbu prvků s pozvolným uvolňováním do substrátu.

hnojiva, školkařství, pěstební technologie, okrasné dřeviny

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