New technologies and improvement of nursery stock quality

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ABSTRACT: This four years experimentation work was aimed at research on using various waste organic materials and especially timber bark in cultivation substrates as a substitute of peat. Sixty-four special isolated cultivation beds were established for this purpose, each of 4.8 m^3 volume, in which 11 variants of substrates consisting of different proportions of different components in several replications were tested. Standard substrates Horticultural substrate B and RKS I. were used as controls. Another variant was used as a control for growing tests of plants in containers. All tested substrates were enriched with hydroabsorbent TerraCottem. In some variants reserve fertilisers with slow release of nutrients (Silvamix Forte) were applied. For cultivation testing of studied substrates four ornamental tree species (*Alnus glutinosa, Fraxinus excelsior*, *Salix alba, Salix matsudana*) were chosen. The best evaluated variants were the ones containing 50 and 75% of bark in combination with sand. The worst was the variant composed of chips and sawdust. Thanks to the use of hydroabsorbents, even the variant containing 100% of sand appeared to be very good. The tested trees had different reactions to the different types of substrates depending on their species requirements. The limiting growth factor for *Alnus* was the content of water in the substrate. Similarly, the content of available nutrients in the substrate was essential for *Fraxinus*. The hardwood cuttings of *Salix* not only rooted into the substrate in a few weeks, but also formed above-ground parts of the required sizes. Obtained data on growth parameters differed according to the diversity of requirements of the different studied species.

Keywords: nursery; cultivation technology; bark substrates; *Salix*; *Fraxinus*; *Alnus*

The possibilities to use bark, a secondary waste obtained when processing timber, are a continual research objective. Bark was previously considered as a waste material only (its effective disposal was the only research subject), however, now it is studied as a potential renewable source of energy (sustainable development in the frame of this project) and even as an alternative source of organic matters in horticulture, forestry as well as in garden and landscape architectures. One of the possibilities to valorise bark is to use it in cultivation substrates. Nowadays cultivation substrates have been standardised and are all based on peat. At the present time, the European market is temporarily saturated with peat coming from the ex-countries of USSR but its price gradually rises. The pressure on the protection of such hardly renewable resources also increases (Gorzelak 1998; Van Cotthem 1996).

Countries with advanced nursery practice have already been working for many years on the possibilities to replace peat by other materials. Different materials that could substitute or improve low-quality peat are tested as admixtures in substrates. These are traditional materials such as sand, sawdust, composts, organic waste, timber chips, different porous substances with lightening and aerating effects as well as suitable clayey substances that, at given humidity, can present a perfect crumbed structure when mixed with peat. However, horticultural and forestry research mainly deals with the problem of bark use, its usefulness seems to be the most perspective. Bark from coniferous trees, such as pine, spruce and fir, is the most valuable in this field. The best solution is to compost this bark before using it because the use of fresh bark could provoke some inhibition or some toxicity due to the extractive substances it contains. Bark has very valuable physical properties, especially its porosity, its high permeability and its low volumetric mass (Van Cotthem 1996; Dušek 1993).

Some of the most important problems of bark, used in nursery cultivation substrates, are its easy dehydration and its low capacity of nutrient absorption. Consequently, plants are immediately endangered because of drought and lack of nutrients. Absorption capacity of bark is several times lower than peat absorption capacity. Some nurseries do not believe in the use of bark as a cultivation substrate yet. They apprehend unsteady quality of the material and unexpected reactions to fer-

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tilisation and irrigation on cultivation beds as well as on seedlings cultivated in containers (ANONYMOUS 1991). Another question concerns the risk of pest and disease introduction into the nursery. The suggested cultivation technology, using new information, could remove some of the above mentioned stress factors.

The goal of the project was to work out and to practically test a nursery cultivation technology based on the rational use of waste organic material. Abiotic factors influencing the biological process of plants were also observed. This article gathers all observations obtained during the four years experimentation work on bark substrate (SALAŠ, ŘEZNÍČEK 2001). Our research activities tried to solve the two basic problems of bark substrate – easy dehydration and unbalanced nutrition of cultivated trees and shrubs.

MATERIAL AND METHODS

The experiment took place on the fields of Mendel University of Agriculture and Forestry in Lednice (Czech Republic). Sixty-four isolated cultivation beds were established on two experimental fields. The volume of each bed was at least 4.8 m^3. Each year, the number of experimental plots was 32, i.e. 64 altogether. Each experiment lasted for two years (1999–2000, 2000–2001). Twelve variants were prepared from different components (bark, timber chips, sawdust, sand, peat, reserve and additional fertilisers, hydroabsorbents) (Table 1). Variants 1–10 were repeated three times in each year of experiment establishment (i.e. 1999, 2000). Differently, only variants No. 11–12 were not repeated. Standard substrates Horticultural substrate B and RKS I. were used as controls. Application of fertilisers and hydroabsorbents: 0.8 kg/m^3 of urea, 0.7 kg/m^3 of Fosmag – converted to the used bark volume, 3.0 kg/m^3 of release fertiliser Silvamix Forte, 0.5 kg/m^3 of hydroabsorbent TerraCottem (converted to the used bark volume).

The same assortment and the same numbers of trees and shrubs were planted on each 16 m^2 plot (replication). The cultivation technology was tested on the following species of trees: *Alnus glutinosa, Fraxinus excelsior* (bare-root seedlings –1/0), *Salix alba, Salix matsudana* (hardwood cuttings). During the experiment, abiotic factors influencing the biological development of plants were observed (temperature in substrate, temperature of air in the vegetation season, relative air humidity in the vegetation season, humidity of substrate). Electronic sensors HOBO and VIRRID were used for monitoring these factors. The evaluation of this experiment took place from 1999 to 2001. The tested plants (*Alnus*, *Fraxinus*) that had been propagated by seeds were cultivated on experimental plots for two years (nursery cultivated plants 1/2), those propagated by hardwood cuttings (*Salix*) were tested for only one vegetation period (nursery cultivated plants 0/1). The length and the number of shoots were observed on all plants, the diameter of the base was measured only on plants grown from seedlings (in the second year, at the time of harvesting – October 2000, 2001). Statistical evaluation was done using the programme Unistat, it included analysis of variance and serial comparisons by Scheffe's method.

The choice of the reserve fertiliser applied in our experimental substrates was limited by two main requirements: very low release of nutrients in the frame of the nursery cycle (two to three years) and independence of temperature on the release rate of nutrients (because of contained bark, we expected the substrate to warm up more than a usual horticultural substrate). Considering these two require-

Table 1. Proportion of the different components in the cultivation substrate (%)

Variant No.	Crunched bark	Filiform peat	Coarse-grained sand	Chips	Sawdust	Standard substrate
1	–	–	–	–	–	100
2	100	–	–	–	–	–
3	75	25	–	–	–	–
4	50	50	–	–	–	–
5	75	–	25	–	–	–
6	50	–	50	–	–	–
7	25	–	75	–	–	–
8	50	–	50	–	–	–
9	50	–	20	30	–	–
10	50	–	20	–	30	–
11	–	–	–	–	–	100
12	–	–	100	–	–	–

Note: 1. hydroabsorbent is used in variants number 1 to 12, fertiliser in variants 1 to 7 and 9 to 12
2. variant No 11: trees were planted in containers
3. standard substrates: sample plot 1 (1999–2000): Horticultural substrate B
sample plot 2 (2000–2001): RKS I.

Table 2. Average values of growth parameters – *Alnus incana*

Variant No.	Sample plot 1					Sample plot 2				
	Height of plants		Number of lateral shoots		Base diameter	Height of plants		Number of lateral shoots		Base diameter
	1999	2000	1999	2000	2000	2000	2001	2000	2001	2001
	(mm)	(mm)	(nb)	(nb)	(mm)	(mm)	(mm)	(nb)	(nb)	(mm)
1	499	1,302	13.3	34.2	19	582	1,762	13.4	34.6	23.1
2	431	1,824	12.4	45.3	28	618	1,802	13.2	36.6	26.2
3	515	1,577	13.5	33.8	21	717	2,049	14.0	40.1	30.1
4	606	1,621	15.7	30.0	20	673	1,795	14.7	37.9	27.4
5	378	1,825	9.5	42.8	28	602	1,761	12.3	37.7	24.4
6	488	1,614	13.2	35.0	24	523	1,716	15.0	38.7	23.8
7	459	1,730	14.3	41.5	27	513	1,797	13.5	39.3	25.1
8	485	1,853	13.1	35.2	21	575	1,994	11.4	39.1	27.4
9	419	1,975	12.6	42.4	31	444	1,870	10.1	36.1	25.3
10	507	1,378	12.3	32.9	22	661	1,880	14.0	39.1	28.8
11	425	1,523	12.4	23.5	13	299	1,534	7.4	29.1	19.3
12	398	1,469	9.5	33.1	22	489	1,701	15.9	38.5	22.5

ments, the Czech fertiliser Silvamix appeared to be optimal. Mineral fertilisers from the range Silvamix are special full fertilisers with a high content of nutrients. They are characterised by a gradual long-term release of nutrients. Nutrients are available not only during one vegetation period, but also during the following vegetation. In our experiment, the fertiliser Silvamix Forte was applied as a powder (application into the substrate).

The hydroabsorbent TerraCottem was also used in our experiment. It is a complex preparation, composed of hydroabsorbent polymers, of fertiliser, of growth regulators and of a structural part. This product was used in our experiment because it prevented the substrate to dry off. However, even if it mainly retains water, it also contains a smaller quantity of nutrients that can be used by the plants later – the availability of applied fertiliser is consequently increased.

RESULTS

The proposed and tested technology is based on the cultivation of woody species in bark substrates using reserve fertilisers with slow release of salts (Silvamix Forte) and special hydroabsorbents (TerraCottem). The basic growth parameters are documented in Tables 2 to 7.

Alnus incana

On the first experimental plot of variant 1, *Alnus* trees showed the smallest average size (according to statisti-

Table 3. Statistical analysis (*Alnus incana*)

		Factor: height of plants		Factor: number of shoots		Factor: base diameter	
Alnus 2000 – scattering analysis							
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level
Variants	11	7,706.067	**	678.593	**	3,648.860	–
Residuum	277	1,703.716		199.296		4,593.266	
Total	288	1,912.659		215.981		4,560.391	
Alnus 2001 – scattering analysis							
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level
Variants	11	3,480.077	**	111.758	*	154.051	**
Residuum	277	984.918		49.257		46.970	
Total	288	1,080.219		51.644		51.060	

Note:
** – Highly significant difference at 0.01 significance level
* – Significant difference at 0.05 significance level
– – Insignificant difference

Table 4. Average values of growth parameters – *Fraxinus excelsior*

Variant No.	Sample plot 1					Sample plot 2				
	Height of plants		Number of lateral shoots		Base diameter	Height of plants		Number of lateral shoots		Base diameter
	1999 (mm)	2000 (mm)	1999 (nb)	2000 (nb)	2000 (mm)	2000 (mm)	2001 (mm)	2000 (nb)	2001 (nb)	2001 (mm)
1	270	930	1.4	6.0	20	366	660	1.3	4.4	13.8
2	161	591	1.3	2.4	15	214	392	1.9	3.6	10.6
3	153	456	1.4	3.3	13	220	485	1.6	4.1	12.0
4	178	636	1.6	3.7	22	221	475	1.6	3.4	12.5
5	190	582	1.8	3.5	19	182	328	1.3	3.3	9.6
6	219	634	1.8	3.7	17	218	458	1.4	5.2	11.3
7	269	676	1.7	3.2	16	191	412	1.4	4.1	10.5
8	195	524	1.5	2.1	14	201	321	1.3	2.9	8.7
9	177	378	1.7	1.8	12	195	318	1.3	3.6	9.3
10	143	485	1.7	2.8	14	199	424	1.6	4.7	11.4
11	181	499	1.3	3.1	10	223	333	1.3	2.6	8.8
12	169	461	2.3	3.7	15	177	379	1.4	3.9	11.7

cal analysis, interval 95%) compared with other plants in other variants. The only exception was variant 12, which did not differ statistically from the control. Concerning the parameter "number of lateral shoots", control variant 1 was statistically different from two variants only, variants 7 and 5. On the plants harvested on the second experimental plot, the parameter "height of plants" of control variant 1 did not differ statistically from any other variants. However, the parameter "number of lateral shoots" of control variant 1 showed to be statistically different from variants 3, 7 and 8. When considering the parameter "base diameter", variants 3, 10 and 8 were different from control variant 1.

Fraxinus excelsior

On the first experimental plot, plants of the species *Fraxinus* in variant 1 had statistically the largest average height in comparison with all other variants (according to statistical analysis, interval 95%). The number of lateral shoots in the plants of variant 2 was statistically highest in comparison with other variants. This variant is the only one that differs from control variant 1. Plants of control variant 1 harvested on the second experimental plot had a statistically larger height than all other plants of other variants. Control variant 1 showed a statistically higher number of lateral shoots than variants

Table 5. Statistical analysis (*Fraxinus excelsior*)

		Factor: height of plants		Factor: number of shoots		Factor: base diameter	
Fraxinus 2000 – scattering analysis							
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level		
Variants	11	1,147.412	**	1.928	**		
Residuum	571	53.565		0.725			
Total	582	74.239		0.748			
Fraxinus 2001 – scattering analysis							
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level
Variants	11	3,994.838	**	17.170	**	91.859	**
Residuum	382	297.570		3.023		9.868	
Total	393	401.055		3.419		12.163	

Note:
** – Highly significant difference at 0.01 significance level
* – Significant difference at 0.05 significance level
– – Insignificant difference

Table 6. Average values of growth parameters – *Salix alba* and *Salix matsudana Tortuosa*

Variant No.	*Salix alba* Sample plot 1 1999		*Salix matsudana Tortuosa* Sample plot 2 2000	
	Height of plants (mm)	Number of lateral shoots (nb)	Height of plants (mm)	Number of lateral shoots (nb)
1	1,560	18.7	1,312	12.6
2	1,473	12.6	985	8.6
3	1,017	10.0	1,094	11.6
4	1,503	17.4	949	13.0
5	1,573	16.7	1,157	7.6
6	1,705	16.8	1,181	9.9
7	1,664	18.0	1,472	15.3
8	1,745	19.0	1,287	12.2
9	1,551	15.1	1,167	10.5
10	1,674	15.5	1,343	16.3
11	–	–	–	–
12	1,441	14.8	644	3.2

4, 5, 8 and 11. The average base diameter of the plants of control variant 1 was statistically higher than in other variants except for variant 4, which did not differ statistically from the control variant.

Salix alba, Salix matsudana Tortuosa

Plants of the species *Salix alba* on the first experimental plot showed a statistical difference between control variant 1 and variant 3 (according to statistical evaluation, interval 95%). Control variant 1 had the statistically highest number of lateral shoots of all other variants except for variants 7 and 8, which were not statistically different. Plants of the species *Salix matsudana* on the second experimental plot showed that variants 2, 9, 4 and 12 had a statistically lower height than control variant 1. Considering the analysis of the number of lateral shoots, no variant was statistically different from the control.

DISCUSSION

Plants of the species *Alnus* were used as an indicator of the used hydroabsorbent utility because they require the highest content of available water in soil. The irrigation of the experimental plots (except at the time after

Table 7. Statistical analysis (*Salix alba, Salix matsudana Tortuosa*)

		Factor: height of plants		Factor: number of shoots	
Salix alba 1999 – scattering analysis					
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level
Variants	11	12,530.899	**	236.33	**
Residuum	287	2,240.912		74.547	
Total	298	2,620.743		80.527	
Salix matsudana 2000 – scattering analysis					
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level
Variants	11	6,631.865	**	211.764	**
Residuum	163	1,217.282		50.586	
Total	174	1,559.583		60.776	

Note:
** – Highly significant difference at 0.01 significance level
* – Significant difference at 0.05 significance level
– – Insignificant difference

planting trees) was a lot lower than under other cultivation technologies. The year 2000 was very suitable for that kind of observation because of its uneven temperatures and humidity. The tested plants that were planted in a bark substrate one or two years earlier (planting in 1999 and 2000) overcame the unfavourable period of time without any bigger problem and with a minimal need of supplementary irrigation. However, the control substrate, whose composition was based on peat, suffered a lot from dryness when too little irrigated. BAILLY (1989) arrived at similar conclusions with his experiments on compost of plant residues, peat and substrate.

Evaluation of harvested plants was marked by a very dense and quality root system, mainly for the species *Alnus*. Bare-root plants with good quality root systems have a better chance to get over stress situations that can occur during their transport, their storage and their planting in the definitive place. This period of time is decisive for further development of plants. WALMSLEY et al. (1991) also paid attention to the water stress occurring after transplantation of woody plants. The same author mentioned that the size of the root system is a predominant factor for water uptake. However water stress can be minimised by transplanting plants with a rich root system and by securing their following development. ÖRLANDER (1985) warns that insufficiency in the growth and survival of plants is often a result of bad water uptake due for example to the use of peat or any substrate having large pores.

The tested plants responded differently to the different types of substrates depending on their own requirements. For *Alnus*, the limiting growth factor was the content of water in the substrate but the advantage of that type of trees is their symbiosis with soil bacteria (they enrich the soil with nitrogen). A very important indicator for *Fraxinus* was the content of available nutrients in the substrate. Woody cuttings of *Salix* not only showed a very fast rooting in the substrate but also rapidly established well developed aboveground parts. Obtained information on growth parameters varied in agreement with the different requirements of the used species of trees.

Hardwood cuttings of both species of the genus *Salix* that were examined in this experiment responded to all cultivation substrates very well. This suggested a possible new and cheaper type of production of this type of trees responding to the quality requirements of young plants. The main advantages of this cultivation technology are the rich root system of harvested plants and the easy harvest of bare-root plants. Comparison of obtained data allows to state that out of the three studied genera the genus *Salix* is the most resistant to stress conditions and the most effectively benefits from the cultivation conditions (in the absence of variant 11 that was not set up for this genus). However it is necessary to remind that this genus has a shorter cultivation cycle. The obtained results can also differ in the function of cultivated species or hybrids that are very numerous in the genus *Salix*. However the same comment could be made when using standard cultivation substrates.

The reaction of *Fraxinus* to this type of cultivation technology was completely different. As it was shown thanks to its reaction to the different cultivation conditions, this plant is demanding in nutrients. Plants markedly responded to standard substrates mainly in the second year of cultivation. This was mainly proved by the parameter "height of plants". A hydroabsorbent (that also contains nutrients) was applied in the substrates of all variants. The same dose of reserve fertiliser was applied in all substrates (except for variant 8). In addition, both used standard substrates were fertilised according to the prescriptions of the production company. In the substrates containing waste wood material, a single application of fertiliser, covering the decomposition need of wood material, was done. However in the second year of cultivation, nutrient supply did not correspond to the needs of trees. That is why the "height of plants" increase was reduced. However no such differences were found out on other growth parameters. The comparison of trees cultivated in the same types of substrate but according to a different technology – in cultivation beds and in containers (variants 1 and 11) – was very interesting. The obtained information shows that the tested cultivation technology is less usable for the production of *Fraxinus* mainly with respect to securing an even content of nutrients during the cultivation cycle.

Variant 11 (trees in containers) must be considered separately (especially *Alnus glutinosa)*. Under the given regime of irrigation, plants in containers suffered from a distinct lack of water. This was due to the fluctuation of temperature in the root zone and to the limited volume of cultivation substrate. This was also observed when the plants cultivated in the same type of substrate but with different technology were compared – it means in cultivation beds and in containers (variants 1 and 11). This effect was due to the different absorptive surface area of plant roots. SOUKUP and MATOUŠ et al. (1979) said that the volume occupied by the root system in free soil is on average 10 times larger than the container volume. Of course, it depends on the type of plant and on the type of root system.

These experiments were also carried out with other genera that are not mentioned in this article. They dealt with a broad spectrum of forest and fruit trees, as well as coniferous and evergreen ornamental plants. The global evaluation showed that the best variants were the variants containing the highest content of bark (50%, 75% and 25%) in combination with sand. The worst variant was that containing wood chips (in combination with bark and sand). The optimal composition of the substrate should always be defined for each single genus and should consider the knowledge of genus requirements as much as possible. The proportion of bark should not be higher than 75%. Use of bark at a larger scale could be advised only. The applicability of bark in the substrate was mentioned by many authors, for example KEEVER and COBB (1990) and DUŠEK (1993).

CONCLUSIONS AND SUGGESTIONS FOR NEW TECHNOLOGY

The hypothesis saying that the limiting factor of success is the time period between planting in bark substrate and rooting was confirmed. As long as trees and shrubs get over this period, there is no more risk caused by the type of substrate because trees and shrubs have rooted in the hydroabsorbent structure (SALAŠ 1996). In the mentioned group of trees, *Alnus*, known for its high requirements in water, is uncertain in this respect. That is why it is necessary to transplant the seedlings as early as possible and before their bud burst. When the transplantation is done later, it is necessary to provide irrigation. *Fraxinus* buds earlier. It is very good to propagate *Salix* by cuttings in autumn or in early spring at the latest (the advantage of such type of substrate is its practicability). Hardwood cuttings can use the natural moisture of soil better in combination with its ability to accumulate warmth better (in comparison with open land). And when planting cuttings of *Salix* in autumn, it is not necessary to store the cuttings. The planting of seedlings in autumn was not experimentally verified, however for *Alnus* and *Fraxinus* it should not be a problem.

The basic component of the substrate is quality pine bark (it can be an admixture with spruce bark), crushed and composted or stocked in piles at least. Although in the case of composted bark, applied doses of fertiliser are established in the function of a standard analysis of substrate, the situation is more difficult in the case of mellow bark. When establishing the dosage of reserve fertiliser, we must take into account not only the woody plant requirements but also the organic matter decomposition factors (higher need of nitrogen) and the higher risk of nutrient leaching from the substrate (when irrigation is necessary). Sources of nitrogen in the substrate can be for example urea, ammonium sulphate, reserve fertilisers as well as hydroabsorbent (SALAŠ, ŘEZNÍČEK 2001).

In our experiments, the following composition proved to be very good: 0.8 kg/m^3 of urea (46.4% N), 0.7 kg/m^3 of Fosmag (24.4% P_2O_5, 3.8% MgO) – converted to the used bark volume, 3.0 kg/m^3 of release fertiliser Silvamix Forte (17.5% N, 17.5% P_2O_5, 10.5% K_2O, 9.0% MgO), 0.5 kg/m^3 of hydroabsorbent TerraCottem (converted to the used bark volume). When preparing the substrate, it is very important to mix all components very well. This is important mainly when applying the hydroabsorbent. The possible toxicity of materials such as timber chips and sawdust must not be forgotten; they should be composted.

The care of trees and shrubs during the vegetation is the same as in usual cultivation technology for each group of trees and shrubs (for example broadleaved species, coniferous, evergreen and so on). However, it is necessary to pay greater attention to the fluctuation of nutrients in the substrate depending on the course of climatic factors. It is also essential to control the possible presence of pests imported into the substrate with the waste woody material. However it is impossible to establish a universal fertilisation technology; this is due to the large assortment of trees and shrubs cultivated in nurseries, to their very different requirements and to the differences in microclimatic conditions in each nursery.

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ABSTRAKT: Příspěvek se zabývá problematikou odpadních materiálů ze zpracování dřeva a jejich možného využití do pěstebních substrátů. Publikované výsledky byly získány v rámci projektu GA521/98/P248, později i s přispěním projektu MSM 435100002. Nejdůležitějším výstupem ukončeného výzkumného projektu je návrh pěstební technologie, založené na principu pěstování dřevin v kůrových substrátech s využitím speciálních zásobních hnojiv na bázi málo rozpustných solí (Silvamix Forte) a hydroabsorbentů (TerraCottem). Přestože byl projekt řešen u širokého spektra dřevin, příspěvek se zabývá pouze vybranými rody listnatých opadavých dřevin: *Alnus, Fraxinus, Salix*. Při celkovém zhodnocení byly nejlépe hodnoceny varianty s 50% a 75% zastoupením kůry v kombinaci s pískem, nejhorší byla varianta, zahrnující jako komponent štěpky a piliny. Vzhledem k použití hydroabsorbentů a speciálních zásobních hnojiv se velmi dobře jevila i varianta se 100% zastoupením písku. Pokusné dřeviny reagovaly na různé typy substrátů rozdílně v závislosti od svých druhových nároků. U dřevin rodu *Alnus* byl limitujícím faktorem růstu obsah vody v substrátu, pro rostliny *Fraxinus* byl velmi důležitým ukazatelem obsah využitelných živin v substrátu. Dřevité řízky *Salix* dokázaly v substrátech během několika měsíců nejen zakořenit, ale také vytvořit nadzemní část požadované velikosti. V souladu s různorodostí nároků použitých druhů dřevin se lišily i získané údaje růstových parametrů.

Klíčová slova: školkařství; pěstební technologie; kůrové substráty; *Salix; Fraxinus; Alnus*

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