ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS
SBORNÍK MENDELOVY ZEMĚDĚLSKÉ A LESNICKÉ UNIVERZITY V BRNĚ

Ročník LII 6 Číslo 2, 2004

USE OF WASTE MATERIAL IN CULTIVATION SUBSTRATES

P. Salaš

Received: January 26, 2004

Abstract

SALAŠ, P.: *Use of waste material in cultivation substrates*. Acta univ. agric. et silvic. Mendel. Brun., 2004, LII, No. 2, pp. 43-52

Gardeners´ practical experience and experimental work prove the affirmation that the used substrate is a very important base for the production of quality nursery products. It is important to emphasis the complexity and synergy of all factors influencing the ecosystem and there mutual relations. Physical, chemical and biological properties do not separately affect the growth and development of plants. In addition, the relations are not statical but differ in relation with other factors changes. This article is dealing with the possibility to use waste material from timber processing in cultivation substrates. The large scale use of such substrates would enable people to reach a relative independence from peat substrates, of which the global reserve is gradually decreasing.
Our research activities focus on the use of bark. The basic problems of a bark substrate are easy dehydration and unbalanced nutrition of trees and shrubs. The suggested and experimented cultivation technology solves these problems. It is based on the cultivation of woody species in bark substrates, using modern irrigation systems, slow release fertilisers (Silvamix Forte) and special soil conditioners (TerraCottem). This technology was tested on the following species of trees and shrubs: *Malus* and *Buxus*.

nursery production, growing technologies, *Malus*, *Buxus*

Different mineral and organic materials have been used in horticulture for the preparation of cultivation substrates called horticultural earth. Initially they were derived from natural soils. This way, a large number of basic horticultural earths has appeared such as for example leaf-mould or the ones composed from needle-leaves, common heath, turf compost and so on. Thanks to their mixture we obtained substrates corresponding to the special requirement of given genus or species of woody plants.

However these basic horticultural substrates are getting unavailable in the required quantity and quality. This is due to the increase of horticultural production, to the exhaustion of resources and also to the protection of soil and forest fund. The work and time costingness necessary to prepare these substrates is also responsible. Currently standardisation, simplification and unification of cultivation substrates receipts are characteristical. Horticultural production is a highly intensive activity with high additionnal inpus of energy (nutrients, irrigation, protection), thats why it is possible to substitute these substrate components which are not in standard substrates (standard uniform substrates can not fill the specific requirements of the different woody plants groups).

Applied research keeps focusing on the substitution possibilities of peat in cultivation substrates by some other components. A good alternative is the use of waste bark, especially from pine tree and spruce. Bark has very valuable physical characteristics, especially its porosity, water permeability and low volumetric weight. However, it's easy dehydration and low capacity of nutrient absorption constitute some problems. Consequently, plants are immediately threatened because of drought and lack of nutrients. Absorption capacity of bark is several times lower than that of peat. Even though bark contains a high percentage of organic matter and has more nutrients than peat, plants do not benefit from these. On the contrary, the natural decomposition of bark creates a higher need of nitrogen fertilisation. Keever (1990) found that growth index, relative root density and shoot growth increased with higher contents of pine bark in the substrate. Volumetric weight decreased, porosity and irrigation frequency increased with higher percentages of bark in the substrate from 50 to 100%. Dušek (1993) has also advised to mix waste bark material into substrates.

The advantage of fresh bark is its high content of substances that have inhibiting and antiseptic effects, such as catechin, coumarin acid, phenolic compounds, and tannins (Bedrna, 1989). Bark humus (composted bark) is suitable for use in substrates. The absolute density of bark is approximately 0,3g.cm^{-3}, the porosity is 82,3%, and its maximum capillarity is 52,9% (Dubský, Šrámek, 2001). Sawdust and shavings are produced as waste during wood processing. These materials are used as admixtures in mixed substrates only, enhancing their porosity and reducing the volume weight. The absolute density of sawdust and shavings is 0,14g.cm^{-3}, porosity approximately 90%, maximum capillarity is 74,4% (Dubský, 1997). The use of wood chips is not so common in our conditions. The volume weight of wood chips is 0,17 g.cm^{-3}, porosity 89,4% and maximum capillarity 58,1 % (Šrámek, Dubský, 1997). The advantage of wood chips is the fact that unlike bark, it contains no tannins (Rajnoch, 1998). Wider use of other non-traditional materials, such as wood pulp or fibres, coconut peat, rice husk, and coconut fibres is limited by the higher purchase price of these materials (Dubský, 1997). Substrate desiccation and lack of available nutrients can be avoided by mixing water absorbing substances with the soil (hydroabsorbents) and by using slow release fertilisers. Of course, a good irrigation system will always be necessary. Hydroabsorbents, suitable for use in horticulture, have the ability to hold rain or irrigation water and to make it available for plants. Special slow release fertilisers are precoated (fertilisers in capsules). They gradually release nutrients. Their effectivity periods depend on the type of expected use.

MATERIAL AND METHODS

The tested technology is based on the cultivation of trees and shrubs in bark substrates, using modern irrigation systems (Netafim), reserve fertilisers based on slow release salts (Silvamix Forte) and a soil conditioner (TerraCottem). Experiments were carried out at the MUAF in Lednice. Cultivation beds were installed on a freeway field; nursery textiles were laid down and covered with the tested substrates. The volume of each bed was at least 4,8 m^3. In total, 64 test plots were set up in two phases (32 in each phase). All experiments were followed during a two-year cycle with an overlap in the year 2000 (1999-2001). Electronic sensors were used to measure air and substrate temperatures (the HOBO sensor was placed at the surface and in the substrate), substrate humidity (the VIRRIB sensor was placed in the substrate) and air humidity (the HOBO sensor was placed at the surface).

In our experiments, the following composition proved to be very good: 0,8 kg.m^{-3} of urea, 0,7 kg.m^{-3} of Fosmag, 3,0 kg.m^{-3} of release fertiliser Silvamix Forte, 0,5 kg.m^{-3} of hydroabsorbent TerraCottem (converted to the used bark volume). Cultivation substrates were mechanically mixed, using different volumes of the following components: crunched bark, sand, chips, sawdust, peat, slow release fertiliser Silvamix Forte and soil conditioner TerraCottem. Three repetitions of each basic variant were set up in each phase (twelve variants in total). These include 10 basic variants repeated three times and two additional ones (without any repetition). Two standard substrates „Horticultural substrate B“ (in 1999) and „RKS I.“ (in 2000) were used as controls. Table I. shows the composition of each cultivation substrate. The same varieties and the same quantity of trees and shrubs (21 nb) were planted on each of the 16 m^2 plots (repetition): grafted fruit trees (*Malus Mill. ´Topaz´*) and ornamental trees and shrubs propagated by cuttings (*Buxus* L.). The following basic growth parameters were measured in the experimental plants: plant height (first year), plant height (total), length of shoots, number of shoots, trunk diameter measured at the base of the trunk (root base), trunk diameter measured below the crown (trunk diameter). In the *Malus* genus, plant height was measured in the first year of cultivation only, in the second year, a crown was established at the same height in all the plants.Results of growth parameters of trees and shrubs were statistically analysed on Microsoft Excel (Analysis of variance).

The soil conditioner TerraCottem is a mixture of 23 components, belonging to 5 different groups and synergetically favouring plant growth. The composition is as follows: hydroabsorbent polymers (39,5%, a mixture of different polymers), mineral fertiliser (8,75%, both coated and uncoated), organic substances (1,25%), growth activators (0,25%), carrier material (49,75%, SiO_2). Silvamix Forte is a complex fertiliser with a high nutrient content. It is characterised by a gradual long-term release of nutrients and contains the main nutrient nitrogen in the form of urea-aldehydic condensates characterized by their various dissolubility in water, depending on the length of the polycondensate chain. It is a gradual source of nitrogen nutrients. This fertiliser also contains slow release potassium-magnesium bi-phosphate, which ensures a gradual release of other basic nutrients: phosphor, potassium and magnesium. The fertiliser was applied in the form of a soil amendment. From the physiological point of view, the fertiliser is classified among the alkaline ones. Nutrients are available during two subsequent vegetation periods. Content: N (17,5%), P_2O_5 (17,5%), K_2O (10,5%), MgO (9,0%), on the whole 54,4%. As organic materials (bark, chips, chippings) were used in the experiment, it was necessary to proceed to an additional fertilisation in most of the variants containing these organic materials. A classical, industrially produced urea (46,4% N), as well as the chemical Fosmag (24,4% P_2O_5, 3,8% MgO), were used to that effect.

I: *Proportion of the different components in the cultivation substrate*

Variant no.	Proportion of the different components in the cultivation substrate (vol. %)					
	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	Woody plants in containers					100
12	-	-	100	-	-	-

Notes: hydroabsorbent is used in variants number 1 - 12, fertiliser in variants 1 - 7 and 9 - 12

RESULTS AND DISCUSSION

Results of growth parameters of trees and shrubs were statistically analysed on Microsoft Excel (Table IV., V.). This software was also used for the graphical illustration of climatic data during the whole experiment. (1999-2001). Growth parameters of trees and shrubs are given in Table II., III.

The hypothesis, that the limiting factor of success is the period of time between plantation in bark substrate and rooting, was clearly confirmed. If trees and shrubs can pass this period without damage, there is no more risk that the type of substrate causes difficulties, because they have already rooted in the hydroabsorbent particles. Van Cotthem (1990) and Labeke (1994) also came to similar conclusions. This study proved that filiform roots of trees and shrubs, cultivated in a substrate containing hydroabsorbent polymers, directly grow in the hydrogel lumps, which represent their source of water and nutrients. When digging out the tree or shrub, the hydrogel lumps keep sticking to the roots. Consequently, the flux of water and nutrients is not interrupted and the roots can still pump the nutrient solution retained in the hydrogels for a limited time (until the hydrogel lumps run out of water). This is a considerable advantage, mainly for trees and shrubs cultivated in containers (Salaš, 1996). However, transport of bare-rooted trees and shrubs clearly reduces the positive effect of hydrogels (the lumps fall off during manipulation).

A significant reduction of irrigation needs, due to the application of hydroabsorbent polymers in combination with bark substrate, was registered. Unusually high temperatures and low humidity in 2000 were particularly favourable for that kind of observations. The tested trees and shrubs, cultivated in bark substrate from 1999 off, survived this unfavourable time period without any major problems, their need for water being minimal. Although irrigated from time to time, the

II: *Average values of growth parameters – Malus Mill. 'Topaz'*

Variant no.	Average values of growth parameters – *Malus Mill. 'Topaz'*											
	PHASE 1						PHASE 2					
	*Height of plants	Shoots length	Number of shoots		**Root base	***Trunk diameter	*Height of plants	Shoots length	Number of shoots		**Root base	***Trunk diameter
	1999	2000	1999	2000	2000	2000	2000	2001	2000	2001	2001	2001
	mm	mm	nb	nb	mm	mm	mm	mm	nb	nb	mm	mm
1	601	206	2,3	6,2	09	12	560	171	4,2	7,8	8,8	11,9
2	520	227	2,1	7,6	10	12	429	204	2,7	6,1	7,7	10,1
3	578	203	2,3	6,2	10	11	473	219	2,4	7,0	8,9	12,1
4	601	228	2,2	7,0	10	11	455	169	3,4	6,4	7,6	10,6
5	580	212	2,2	6,2	10	12	376	191	2,4	6,7	8,2	11,4
6	640	204	2,4	7,1	10	12	440	219	2,7	7,9	8,6	10,5
7	551	210	2,4	6,0	10	12	483	243	2,8	7,1	8,3	11,3
8	511	214	2,4	5,9	07	09	438	234	2,4	6,5	8,5	11,2
9	450	296	2,1	4,7	09	11	365	239	2,2	4,5	8,4	10,0
10	422	217	2,1	3,9	07	09	442	216	2,4	5,9	8,3	11,1
11	592	205	2,5	6,1	08	10	438	183	3,0	5,4	7,4	9,9
12	596	259	2,7	7,0	11	13	406	158	4,0	8,4	9,1	11,3

Notes: * Plant height (first year)
** Trunk diameter measured at the base of the trunk (root base)
*** Trunk diameter measured below the crown (trunk diameter)

III: *Average values of growth parameters – Buxus sempervirens*

Variant no.	Average values of growth parameters - ***Buxus sempervirens***							
	PHASE 1				PHASE 2			
	Height of plants		Number of shoots		Height of plants		Number of shoots	
	1999	2000	1999	2000	2000	2001	2000	2001
	mm	mm	nb	nb	mm	mm	nb	nb
1	107	204	3,1	21,3	68	113	3,0	13,9
2	82	115	2,5	8,6	64	109	3,1	14,8
3	91	136	2,4	10,6	62	106	3,3	13,3
4	97	156	3,3	14,6	73	115	3,4	14,5
5	94	130	3,4	9,7	53	101	2,9	14,3
6	110	186	3,7	17,9	58	104	2,6	14,5
7	147	209	3,7	15,7	70	98	3,0	14,2
8	83	168	2,0	11,9	50	92	2,7	13,7
9	88	122	1,7	6,9	54	83	3,0	13,2
10	86	154	2,1	10,2	61	103	3,3	14,3
11	79	115	3,7	11,1	63	89	4,4	14,0
12	91	162	4,1	15,2	55	87	3,4	14,9

IV: *Statistical analysis – Malus Mill. ´Topaz´*

Malus Mill. ´Topaz´, analysis of variance (Phase 1, 2000)

		Factor: Height of plants		Factor: Number of shoots		Factor: Root base		Factor: Trunk diameter		Factor: Shoots length	
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level
Variantу	11		**	36,181	**	67,165	**	77,948	**	19266,231	-
Residuum	433			7,834		7,458		9,469		15611,372	
Total	444			8,536		8,937		11,166		15701,921	

Malus Mill. ´Topaz´, analysis of variance (Phase 2, 2001)

		Factor: Height of plants		Factor: Number of shoots		Factor: Root base		Factor: Trunk diameter		Factor: Shoots length	
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level	Mean square	Sig. level
Variantу	111	269274,786	**	26,400	*	11,144	**	20,737	**	42159,271	**
Residuum	533	68642,275		12,262		3,277		4,828		11279,649	
Total	544	72699,182		12,548		3,436		5,149		11904,053	

Notes: ** Highly confirmative difference on 0,01 significance level
* Confirmative difference on 0,05 significance level
\- Not confirmative difference

V: *Statistical analysis – Buxus sempervirens*

***Buxus sempervirens*, analysis of variance (Phase 1, 2000)**						
		Factor: Height of plants		Factor: Number of shoots		
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level
Variranty	11	490,510	**	184,687	**
Residuum	409	63,512		12,708	
Total	420	74,669		17,212	
***Buxus sempervirens*, analysis of variance (Phase 2, 2001)**					
		Factor: Height of plants		Factor: Number of shoots	
Source of variation	d.f.	Mean square	Sig. level	Mean square	Sig. level
Varianty	11	33,923	**	9,866	**
Residuum	419	13,299		3,478	
Total	430	13,827		3,641	

Notes: ** Highly confirmative difference on 0,01 significance level
* Confirmative difference on 0,05 significance level
\- Not confirmative difference

control substrates suffered from drought. Experimental trials were irrigated only five times from January to October 2000. Although the electronic sensor in the substrates showed an important reduction of water reserve in the substrates, this had no negative effect on the plants themselves, even though the temperatures reached tropical levels (in May, June and August). This result, already confirmed by some other published data (e.g. Van Dendeyck, 1991, Mohammed, 1993, Salaš, 1996, Sarvašová, 2001) speaks in favour of the use of hydroabsorbent polymers in substrates. The harvested plants showed a very good and dense root system, increasing survival rates in hydric stress conditions after transplanting to their final emplacement. Bosteels (1991) and Gorzelak (1998) describe similar results. No rooting through the nursery textile was observed.

The global evaluation showed that variants n° 5, 6 and 7 were the best ones. These are the variants with the highest content of bark (75vol.%, 50vol.% and 25vol.%) in combination with sand. The worst variant was n° 9, containing wood chips. Plants of the control variant did not reach their optimal growth. This is due to the lower irrigation volume (the standard substrate dried completely and this caused hydric stress). Similar conclusions were published by Bailly (1989). In his experiments, he used the standard substrate „TKS 2“. In our experiments, and thanks to the use of the water absorbing soil conditioner TerraCottem, the variant containing 100vol.% of sand (variant 12) proved to be good too. No damage of plants, due to reduction of nutrient content, was observed, although this factor remains always capital and quite easily influenced by temperature and rainfall during the vegetation period.

When cultivating *Malus* in these substrates, one should pay attention to the problem of root damage of young grafted plants due to a higher salt content (dew roots of the grafted plants). The first month after planting is critical because of the characteristics of the grafted plants. This danger can also be expected for other fruit trees propagated by a similar technology. Trees and shrubs propagated by cuttings (*Buxus*) showed a lower plant stability. The anchoring root system has a lower quality than the one of seedlings. For these species, the development is slower and their optimal growth was observed in the second and third year of cultivation.

According to these investigations, woody chips can only be used in limited quantity in the substrate composition. When using non-composted woody chips, they can contain toxic substances, which wash up more slowly. They can also appear when using bark. Chips decompose more slowly and can induce a disturbance of the water system around roots. A lot of air pockets are present in the system and this can be unfavourable when planting young plants in the substrate. In our experiments, especially the young apple trees suffered when planted in the substrate with dew roots (plantation in May about three months after grafting).

Sawdust and chippings are not good to be used as fresh materials. They can not only contain phytotoxic substances, but they can also provoke a disturbance of the nitrogen supply to the plant. Decomposition of woody substances can be unbalanced, depending on temperature and humidity. It can even be very intensive in contrast to bark. It is recommended to first compost these waste materials and then to add them to the substrate.

Species, cultivated under this technology, should be carefully chosen considering basic life conditions, the wanted quality characteristics of the produced plants (e.g. trunk straightness) and the type of expedition (bare-rooted plants or not).

When comparing the dimensions of root systems of plants grown in open land, in containers and in experimental beds, it has been shown that the largest ones are developed by plants cultivated in experimental beds, then on the ones cultivated in containers. Plants cultivated in open land have the smallest root systems. When evaluating the possible deformation of the root system, the best cultivation system was the one in open land (as far as the plants were not planted mechanically), followed by plants cultivated in experimental beds (trees and shrubs with a taproot) and ultimately by plants cultivated in containers. However, evaluation of root damages during harvest showed that plants in containers were the less damaged ones, followed by those in experimental beds and by the ones in open land. Harvesting plants from the experimental substrate was quite easy. The only damages were due to the intergrowth of roots from adjacent plant. When digging out the plants from open land, damages were caused not only because of the reason mentioned above, but also because of the strong fixation of roots in the surrounding soil (roots strongly hold to the soil and break during manipulation).

SUMMARY

This article is dealing with the problems of waste materials obtained from timber processing and it describes the possibilities to use these materials in cultivation substrates. The use of such substrates would make nurseries relatively independent from peat substrates, of which the world reserve is gradually decreasing. Countries with advanced nursery practice have already been studying this for many years.

Our research activities focused on the use of bark. The suggested and experimented cultivation technology solves the basic problems of bark substrates: that is easy dehydration of the substrate and unbalanced nutrition of trees and shrubs. The suggested technology is based on the cultivation of woody species in bark substrates, using modern irrigation systems, reserve fertilisers with slow release of salts (Silvamix Forte) and a special soil conditioner (TerraCottem). Experiments were carried out at the MUAF in Lednice (Czech Republic). Cultivation beds were installed on a freeway field. Nursery textiles were put over the local soil and then covered with the substrates to be tested. The volume of each bed was at least 4,8 m^3. In total, 64 test plots were prepared in two phases. All experiments were followed during a two-year cycle with an overlap in the year 2000 (1999-2001).

The global evaluation showed that variants n° 5, 6 and 7 were the best. These are the variants with the highest content of bark (75vol.%, 50vol.% and 25vol.%) in combination with sand. The worst variant was n° 9, the one containing wood chips. In these experiments and thanks to the use of the soil conditioner TerraCottem, the variant containing 100vol.% of sand (variant 12) proved to be good too.

The care of trees and shrubs during the vegetation is, for each group of trees and shrubs (for example broadleaved species, coniferous, evergreen and so on) the same as in an usual cultivation technology. However, it is necessary to pay higher attention to the fluctuation of nutrients in the substrate depending on the course of climatic factors. It is also essential to control the possible appearance 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 of microclimatic conditions in each nursery.

This research project was sponsored by MŠMT Czech Republic and by the Grant Agency Czech Republic (projects GA521/98/P248 and MSM 435100002).

nursery production, growing technologies, *Malus*, *Buxus*

SOUHRN

Využití odpadních materiálů v pěstebních substrátech

Článek se zabývá shrnutím výsledků několikaletého výzkumu v oblasti využití odpadních materiálů vzniklých při zpracování dřeva pro potřeby školkařské produkce. V experimentech byly testovány různé pěstební substráty, převážně kůrové. Uplatnění těchto substrátů by umožnilo získat větší nezávislost na rašelině. Navržená a experimentálně vyzkoušená pěstební technologie z velké části řeší základní problém kůrových substrátů – snadnou vysýchavost substrátů a nevyváženou výživu dřevin. Základem navrhované technologie je pěstování dřevin v kůrových substrátech s využitím moderní závlahy, zásobních hnojiv na bázi málo rozpustných solí (Silvamix® Forte) a speciálních hydroabsorbentů (TerraCottem®). Výzkumný projekt byl řešen na experimentálních plochách MZLU v Brně, Lednice. Na pokusné ploše bylo vytvořeno celkem 64 izolovaných pěstebních koryt, z různých komponent (kůra, štěpky, hobliny, písek, rašelina, kontrolní substrát, hnojiva, hydroabsorbenty) bylo vytvořeno celkem 12 pokusných variant. Pěstební technologie byla vyzkoušena u dřevin z rodu *Malus* a *Buxus*. Při celkovém zhodnocení byly nejlépe hodnoceny varianty s 50%, 75% a 25% (objemovým) zastoupením kůry v kombinaci s pískem, nejhůře byla vyhodnocena varianta zahrnující jako komponenty štěpky. Také rostliny v kontrolní variantě nedosahovaly optimálního růstu a to z důvodu přesychání substrátu (aplikace hydroabsorbentů umožnila snížit závlahové dávky, standardní substrát s vysokým procentickým objemem rašeliny ovšem přesychal). V experimentech se (vzhledem k použití hydroabsorbentů) jako velmi zajímavá jevila i varianta se 100% (objemovým) zastoupením písku. Pěstování dřevin rodu *Malus* v kůrových substrátech je ovšem problematické. Důvodem je jakostní požadavek na výpěstek s rovným kmínkem (při použití slabě vzrůstných podnoží je problematické ukotvení rostlin v prvním roce po vysázení, problematické je i vyvazování rostlin k tyčím).

školkařská produkce, pěstební technologie, *Malus*, *Buxus*

REFERENCES

BOSTEELS, D.: Použití TerraCottemu při pěstování Simmondsia chinensis v Paraguay, studie Agri Arid World Consultants (Belgie), 1991, ed. Absys Miroslav, 1998, 13 s.

BEDRNA, Z.: Substráty na pestovanie rastlín - základy pestovania, Príroda, Bratislava, 1989, ISBN 80-07-00012-7, 260 s.

DUBSKÝ, M.: Pěstební substráty I-XII, In: Informace pro zahradnictví (ovocnářství, zelinářství, květinářství), série článků, nakl. Strategie, Praha, 1997, čísla 1-12

DUBSKÝ, M., ŠRÁMEK, F.: Pěstební substráty s kompostovanou kůrou, Informace pro zahradnictví, (ovocnářství, zelinářství, květinářství), nakl. Strategie, Praha, 2001, číslo 2, s. 16

DUŠEK, V.: Využití drcené kůry a štěpky k zlepšení kvality rašelinových substrátů. Lesnická práce, 1993, 72, č.10, s. 299 – 301

GORZELAK, A.: Zastosowanie torfu i kory w hodowli sadzonek drzew leśnych w środowisku kontrolowanym Sylwan, 1998, R.142, nr. 8, s. 35-41

KEEVER, G. J., COBB, G. S.: Plant Response to Container Planting Methods and Media. Journal of Environmental Horticulture. 1990, 8, č.4, 189-192

LABEKE, V.: TerraCottem for Ornamental Potted Plants, Part I: Shrubs. Scientific Study by the National Horticulture Research Center (P.C.S.), Destelbergen, 1994, 13 p.

MOHAMMED, J. A.: Vliv TerraCottemu na půdní a vodní produktivitu Alfalfa biomasy, studie Arabian Gulf University, College of Applied Sciences, Bahrain, 1993, ed. Absys Miroslav, 1998, 12 s.

RAJNOCH, M.: Dřevní odpad – součást půdních substrátů, Modernizace výukového procesu u předmětů ovocné, okrasné školkařství a ovocnářství: MZLU, Brno, 1997, s. 82 – 85, ISBN 80-7157-311-6, 111 s.

SALAŠ, P.: Analýza vybraných druhů okrasných rostlin ve vztahu k různým pěstitelským podmínkám. Ph.D. Thesis.. Lednice: Mendelova zemědělská a lesnická univerzita Brno. Fakulta zahradnická, 1996, 243 s.

SARVAŠOVÁ, I.: The use of TerraCottem in Forest Nurseries. In: „9th International Conference of Horticulture“, Volume 3, ISBN: 80-7157-524-0, s. 589 – 594, Lednice, MUAF, 2001, 688 s.

ŠRÁMEK, F., DUBSKÝ, M.: Náhrada rašeliny v pěstebních substrátech, 70 let zahradnického výzkumu v Průhonicích, VŠÚOZ, Průhonice, 1997, ISSN 0374-5651

VAN COTTHEM, W.: Použití TerraCottemu při

zalesňování v Burkina Fasu, studie University of Ghent, Laboratory for Plant Morphology, Ghent, 1990, ed. Absys Miroslav, 1998, 14 s.
VANDENDEYCK, A., BOEDT, L.: Použití TerraCottemu u palmových stromů v Guiney, studie zemědělského oddělení Socfinco, Brussels, 1991, ed. Absys Miroslav, 1998, 12 s.

Address

Dr. Ing. Petr Salaš, Ústav šlechtění a množení zahradnických rostlin, Mendelova zemědělská a lesnická univerzita v Brně, Valtická 337, 691 44 Lednice, Česká republika