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Crushed Rockwool as a Component of Growing Substrates

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Abstract

The possibility of peat replacement by crushed water absorbent rockwool in amount of 25 and 35% vol. in four types of substrates (peat one, 3 mixtures with alternative components - green waste compost and composted spruce bark) was verified in the experiments with ornamental shrubs and perennials in containers and with pot plants. Chemical (content of available nutrients and potential for nitrogen fixation) and physical (water capacity) properties of the components and substrates were determined. In the peat substrate, the addition of rockwool affected positively the plant growth. It increased water capacity and improved wettability of the peat substrate after irrigation. Plants grown in mixtures with lower content (to 40% vol.) of alternative components also had good market value. In mixtures with higher content of alternative components (65% vol.) lower water capacity and high potential for nitrogen fixation showed negatively. The addition of rockwool to substrates with alternative components had no significant effect. The addition of 25 or 35% vol. crushed rockwool can replace peat in peat substrates and in mixtures with alternative components without making the quality of substrates and the plant growth worse.

INTRODUCTION

Besides peat, two main peat alternative components, composted bark and green waste compost are used for preparing growing substrates in the Czech Republic. Crushed water absorbent rockwool, a waste material from production of rockwool cubes and slabs for hydroponics, is the other perspective component.

Rockwool is used in volumetric proportions 10–60% to replace peat and to improve physical properties of growing substrates. Heiskanen (1995) proved that addition of 25 or 50% vol. of rockwool in pure peat substrates increased available water content (water content retained between –1 and –10 kPa matric potential), without increasing water content at –1 kPa matric potential. The addition of 20% vol. rockwool into pine bark substrates with composts (Bilderback and Fonteno, 1993) increased moisture retention. Also blended recycled rockwool (20–60% vol.) was successfully used as a component of peat-based media (Riga et al., 2003). It slightly decreased water content at -1 kPa, but available water content was the same as in peat substrates.

The use of alternative components with low level of decomposition (bark, composts with high content of woody chips or saw dust) brings a risk of nitrogen tie-up (Hartz et al., 2000). It is necessary to set up fertilization systems compensating possible lack of this nutrient. Disadvantage of composts is the high content of soluble salts and of available potassium. Proportion of composts in growing substrates is limited by these properties (Wilson et al., 2002; Fischer, 1998). The aim of this study was to evaluate the influence of rockwool addition on physical and chemical properties of various types of substrates and on the growth of the plants.

MATERIALS AND METHODS

Four basic types of substrates were prepared (ratio by % vol.): P - sphagnum peat (100), C - peat/green waste compost (75/25), B - peat/composted spruce bark (60/40), M - mixture of peat/compost/bark (35/25/40). To each type of substrate 0, 25 or 35% vol. of rockwool was added and the corresponding part of peat was decreased. Twelve variants of substrates were prepared, the letter marks the type of substrate, the number the percentage of rockwool.

Blond milled peat, fractioned into 0–20 mm of low degree of decomposition (H_3 on von Post scale) from Lithuania was used. The wastes (grass, leaves, woody chips) from the maintenance of public green spaces were composted for seven months. Spruce bark was composted for two years without nitrogen addition at paper mill disposal site. Crushed water absorbent rockwool was a waste from production of cubes for hydroponics. All alternative components were fractioned into 0–20 mm.

Chemical properties of substrates were determined before and two weeks after application of soluble preplant fertilizers. Electric conductivity and pH value of dry samples were estimated in water extract 1w:10v, the content of available nutrients was estimated in Göhler leaching extract (0.52 M CH_3COOH, 0.05 M CH_3COONa) 1w:10v (Soukup et al., 1987). Potential for nitrogen fixation was evaluated using incubation test after addition of 1000 mg N per litre of component or substrate (Hoffmann, 1997). Physical properties of the components and substrates: bulk density, total porosity, container capacity, and air content were determined using 7.5 cm high porometer (Fonteno, 1996).

During the experiment in greenhouse with *Impatiens* pot plants the changes of water and air content between two irrigations were found by weighing the pots with standard height 7.5 cm. Container capacity of substrates was determined one hour after irrigation and another irrigation started when water content in most substrates dropped to 60% of laboratory determined container capacity.

According to the chemical properties of components and nonfertilized substrates the dosage of fertilizers and limestone was chosen. To substrates P0-35 one $g.L^{-1}$ of NPK (14% N/16% P_2O_5/18% K_2O) fertilizer was added. The base dosage of limestone 6 $g.L^{-1}$ was decreased according to the amount of rockwool to 5 and 4 $g.L^{-1}$. To substrates C0-35 and M0-35 only 0.4 $g.L^{-1}$ of N fertilizer (27% N) was added, no limestone was used. To substrates B0-35 0.7 $g.L^{-1}$ of NP (26/14) fertilizer was added. The base dosage of limestone 3 $g.L^{-1}$ was decreased according to the amount of rockwool to 2.5 and 2 $g.L^{-1}$.

Substrates were tested in experiments with woody plants (*Spiraea niponica, Potentilla fruticosa*) and perennials (*Ruta graveolens, Phuopsis stylosa, Veronica teucryum*) cultivated outdoor in containers and with pot plants (*Salvia farinacea, Impatiens* New Guinea, *Chrysanthemum* × *grandiflorum*) cultivated in the greenhouse. Before planting the woody ornamentals dosage 4 $g.L^{-1}$ of controlled release fertilizer Osmocote standard 5–6 (15/10/10) was added to each substrate. Other plants were fertilized by liquid feeding containing 0.2% solution of NPK (19/6/20) in intervals 7–14 days. According to the potential for nitrogen fixation the supplementary nitrogen fertilization of substrates M0-35 and B0-35 was formulated three weeks after planting, 75 mg N per litre of substrate was applied by top dressing (woody plants) or by liquid feeding (perennials, pot plants). Fresh weight of all plants and dimensions of pot plants were measured. All the data sets were tested for normality and analysed by ANOVA and Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The composition of substrates influenced their chemical properties (Table 1). The compost had high content of available K and Ca and P and low content of available nitrogen. Composted bark had slightly alkaline reaction and relatively high content of available Ca. The content of available potassium was, in comparison with standard content (250–500 $mg.L^{-1}$) relatively low. Rockwool had slightly acid reaction and low EC value. The addition of compost increased the content of available P and especially K. The used dosage of compost (25% vol.) was considered as maximum according to the high content of these nutrients and soluble salts (high EC value). The addition of bark increased the content of available K and Ca and pH value. On these results the final dosage of fertilizers and limestone was based. The addition of rockwool decreased the content of available P and slightly increased content of available K and Ca in all types of fertilized substrates, except available Ca in the peat substrates with lower dosage of limestone.

In mixtures M0-35 with low ratio of peat and in bark there was determined high (decrease over 150 mg N per litre of substrate) potential for nitrogen fixation (Table 2). Low potential was found in all other substrates except the peat-bark B0 without rockwool. The addition of rockwool slightly increased nitrogen immobilization in all substrates with alternative components.

Peat substrate P0 had the highest porosity and container (water) capacity, mixture M0 had the lowest parameters (Table 2). The application of rockwool moderately increased dry bulk density and total porosity in all substrates. In substrates P and B it slightly increased container capacity, in substrates C and M it slightly decreased this parameter. The evaluation of container capacity in growing conditions (experiment with *Impatiens* plants) showed that rockwool increased water content in peat substrate (Fig. 1). Rockwool positively influenced wettability of peat substrate after irrigation. In other substrates the application of rockwool had no great effect on substrate wettability.

Good growth of all tested plants was found in substrate P0 (Table 3). Woody ornamentals and perennials showed good performance also in substrate C0 and *Spirea* in substrate B0. The growth depression was found in mixture M0 with low peat content. *Potentilla* and *Phuopsis* plants showed the highest growth depression, *Impatiens* the lowest one. The addition of rockwool had positive effect on plant growth only in peat substrates P0-35 (*Phuopsis, Ruta, Potentilla* and *Salvia*). Peat replacement by rockwool in other mixtures did not affect plant growth significantly. *Chrysanthemum* and *Veronica* plants showed following growth parameters: substrate P0 was the best, mixtures M0-35 were the worst and no influence of rockwool in all types of substrates was observed.

CONCLUSIONS

Generally the best growth of plants was found in peat substrate, in this type of substrate the addition of rockwool showed significant positive effect. The plant growth in mixtures C were comparable and in mixtures B slightly worse in comparison with peat substrates. But in these cases all plants had good market value. Mixtures M were the worst, lower water capacity and high potential for nitrogen fixation showed negatively. The addition of rockwool to substrates C, B and M had a small effect. The results of the experiments revealed that in used types of substrates it is possible to replace peat by crushed hydrophylic rockwool up to 35% vol. without making the quality of substrates and the plant growth worse.

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Tables

Table 1. Chemical properties of components and fertilized substrates, pH and EC in 1w:10v water extract, content of available nutrients, optimum for growing substrates.

Component/ substrate	pH	EC ($mS.cm^{-1}$)	$N\text{-}NH_4$	$N\text{-}NO_3$	P	K	Ca
					($mg.L^{-1}$)		
peat	4.6	0.19	32	2	14	7	53
bark	7.9	0.29	76	0	18	108	5904
compost	8.3	1.29	74	132	492	3807	7132
rockwool	6.5	0.2	24	0	29	174	923
P0	5.4	0.95	68	52	49	128	938
P25	5.4	1.02	51	61	11	165	873
C0	5.7	0.97	53	73	96	725	1266
C25	6.2	1.07	53	89	45	851	1398
B0	6.6	0.66	68	95	31	93	3678
B25	6.8	0.68	104	98	8	107	5099
M0	7.0	0.83	25	117	99	812	4040
M25	7.2	0.91	18	134	57	1066	6220
optimum	5.5–6.5	to 1.0	sum N 80–200		40–110	160–220	1000–2800

Table 2. The potential for nitrogen fixation of the components and substrates: changes of available nitrogen content after 20-days incubation. Physical properties: BD - dry bulk density, P - total porosity, CC - container capacity.

Component/ substrate	changes of available nitrogen			physical properties		
	$N\text{-}NH_4$	$N\text{-}NO_3$	sum N	BD	P	CC
	($mg.L^{-1}$)			($g.L^{-1}$)	(% vol.)	
bark	–460	35	–425	272	77.8	71.6
compost	–667	552	–115	487	68.6	66.4
rockwool	–21	61	40	103	98.8	75.4
P0	–201	119	–83	112	90.2	87.7
P25	–123	71	–52	116	93.1	88.6
C0	–95	81	–14	182	87.8	83.8
C25	–222	145	–77	203	85.8	81.4
B0	–181	246	66	175	85.8	79.2
B25	–218	151	–68	189	87.6	81.6
M0	–302	84	–218	254	81.4	77.3
M25	–309	21	–288	292	80.2	76.5

Table 3. Eval
letter are
$p<0.05$.

var.	*Spir*
P0	49.6
P25	51.5
P35	54.1
C0	56.2
C25	51.5
C35	45.4
BA	51.7
B25	44.6
B35	43.0
M0	39.7
M25	31.1
M35	32.9

Figures

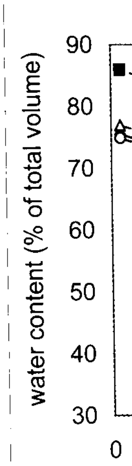

Fig. 1. Cha

Table 3. Evaluation of plants, results of one-way ANOVA, means followed by the same letter are not significantly different according to Duncan's Multiple Range test, $p<0.05$.

var.	Fresh weigh (g)					
	Spiraea	*Potentilla*	*Ruta*	*Phuopsis*	*Impatiens*	Salvia
P0	49.6 abc	80.7 bcd	12.9 bcd	20.0 b	40.4 a	64.2 bcde
P25	51.5 abc	109.5 a	15.1 abc	22.9 ab	36.9 a	66.8 abcd
P35	54.1 ab	108.8 a	17.2 a	24.6 a	37.2 a	72.8 ab
C0	56.2 a	99.7 ab	15.0 abc	22.0 ab	31.8 b	74.3 a
C25	51.5 abc	82.7 bcd	12.1 cd	14.2 cd	28.1 bc	70.5 abc
C35	45.4 bcd	92.2 abc	16.1 ab	16.2 c	29.3 bc	67.2 abcd
BA	51.7 abc	83.7 bcd	9.8 def	12.5 de	27.9 bc	64.2 bcde
B25	44.6 bcd	77.5 cd	11.0 de	11.6 def	27.2 bc	61.3 cde
B35	43.0 cd	74.4 cde	11.1 de	13.0 d	27.6 bc	63.8 bcde
M0	39.7 de	69.4 de	8.3 ef	8.9 fg	28.4 bc	59.8 de
M25	31.1 e	49.1 f	8.1 ef	9.8 efg	25.5 c	55.5 e
M35	32.9 e	58.4 ef	6.1 f	8.5 g	24.5 c	55.4 e

Figures

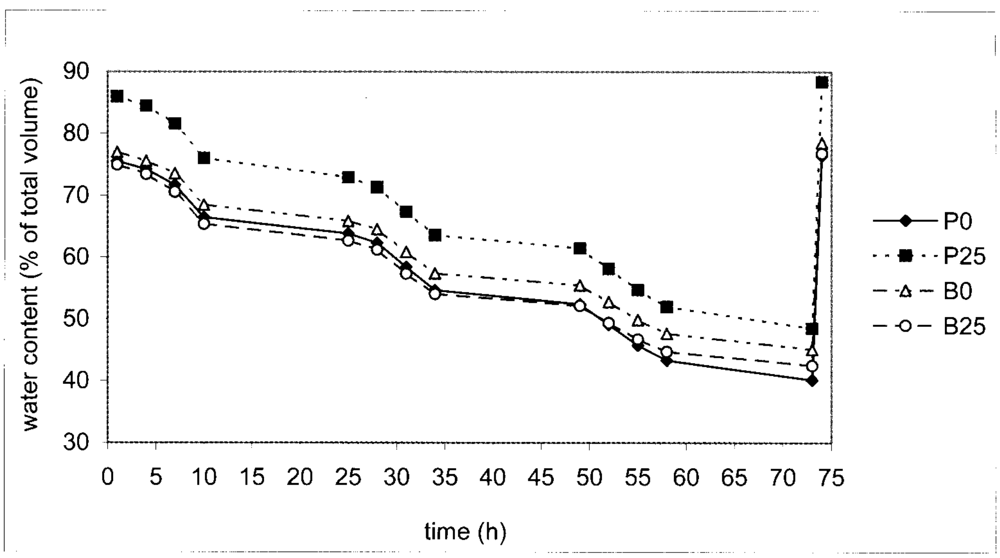

Fig. 1. Changes of water content in substrates P0-25 and B0-25 between two irrigations.