The effect of rockwool on physical properties of growing substrates for perennials

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ABSTRACT: The possibility of peat replacement with crushed water absorbent rockwool in growing substrates in the amount of 35% vol. was verified in the experiment with perennials in containers. Three types of substrates, i.e. peat, and two mixtures of peat with alternative components – green waste compost (25% vol.) or composted spruce bark (40% vol.) were compared. A sand box in the range of –0.5 to –10 kPa was used to determine retention curves and other physical properties of the components and substrates. The addition of rockwool to the peat substrate increased content of air and easy available water, the plant growth was not affected. Plants grown in substrates with alternative organic components were smaller in comparison to peat substrate. The growth of perennials significantly decreased, mainly in substrates with bark, but the plants had good market value. The addition of rockwool to these substrates had no significant effect on the growth. Crushed rockwool in the amount of 35% vol. can replace peat in peat substrates and in mixtures with alternative components.

Keywords: peat; alternative organic components; crushed rockwool; retention curves; perennials

Besides peat, two main peat alternative organic components, composted bark and green waste compost are used for preparation of growing substrates in the Czech Republic. Crushed water absorbent rockwool, a waste material from production of rockwool cubes for hydroponics, might be another prospective component. It has a very high water capacity, but it has low ability to retain water (Fonteno 1996).

In hydroponics systems rockwool substrates (slabs) are used very close to the saturation, typically with suction between 0 and 2 kPa. The hydrophysical properties are influenced by the density (Bougoul et al. 2005), substrates with higher density have higher water capacity; however, rockwool substrates with different density have a very similar behaviour for suctions higher than 1 kPa. When the suction increases up to 5 kPa, the water content decreases and tends towards 0.

Crushed rockwool is added to peat-based substrates in volumetric proportions of 10–50% to improve their physical properties and to replace peat. 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 water potential), without increasing water content at –1 kPa water potential. Adding 20% vol. of rockwool into pine bark substrates with composts (Bilderback, Fonteno 1993) increased their moisture retention. Peat replacement by crushed water absorbent rockwool in amount of 25 and 35% vol. increased water capacity of organic substrates and improved wettability of the peat substrate after irrigation (Dubský, Šrámek 2008).

Also blended recycled rockwool (20–40% vol.) was successfully used as a component of peat-based media (Riga et al. 2003). It slightly decreased water capacity, but available water content was the same as in peat substrates.

A main disadvantage of composts is their high content of soluble salts and available potassium. Proportion of composts in growing substrates is limited by these properties (Wilson et al. 2002). Composted bark is used in proportions of 20 to 40% vol. to improve rewetting and to increase the air content of mixtures (Dubský, Šrámek 2007).

The aim of this study was to evaluate the influence of rockwool addition on physical properties of organic substrates and on the growth of perennials.

MATERIALS AND METHODS

Three types of organic substrates were prepared (ratio by % vol.): P – sphagnum peat (100), C – peat/compost (75/25), and B – peat/bark (60/40). Further, in each type of substrate 35% vol. of peat was replaced with rockwool (substrates PR, CR, and BR). Blond milled peat of low degree of decomposition (H3 on the von Post scale) from Belarus was used. The compost was prepared from wastes (grass, leaves, woody chips) from the maintenance of public green spaces composted for five months. Spruce bark was decomposed 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 components were fractioned into 0–20 mm.

Physical properties of the components and mixtures, dry bulk density, air and water content were estimated in standard rings with diameter of 5.3 cm (EN 13 041). Retention curves of substrates were measured on a sand box in the range of –0.5 to –10 kPa and categories of water available to the plants were calculated (Verdonck et al. 1983; Prasad, O'Shea 1999). Preparation and saturation of samples were carried out according to the EN 13 041. An additional saturation was added after 48 hours on the sand box at the pressure of –1 kPa (point 7.3). Then the upper ring was removed and the fully saturated sample was placed on the sand box. Particle density for calculating total pore space was measured using a water pycnometer. Organic matter content was estimated according to the EN 13 039.

The components and the substrates were analyzed for chemical properties according to the European Standards. Electric conductivity (EN 13 038), pH value (EN 13 037), and content of available calcium (EN 13 652) were determined in water extract (1:5 vol-vol), content of other available nutrients (EN 13 651) by CAT extraction (0.01 mol/l $CaCl_2$ and 0.002 mol/l DTPA) with the extraction ratio of 1:5 vol-vol.

The dosage of fertilizers and limestone was chosen according to the chemical properties of components. The peat based substrates P and PR were fertilized with one gram of NPK (14% N, 16% P_2O_5, 18% K_2O) fertilizer with micronutrients per liter of substrate. The base dosage of limestone 6 g/l was decreased according to the rockwool addition to 4 g/l. Only nitrogen fertilizer (ammonium nitrate, 35% N) was added to substrates C and CR with compost, dosage 0.3 g/l was used. No limestone was added. Peat-bark substrates B and BR were fertilized with 0.4 g/l of ammonium nitrate (35% N), 0.2 g/l of potassium sulphate (50% K_2O), and 0.9 g/l of superphosphate (18% P_2O_5). The base dosage of limestone 1 g/l was decreased according to the rockwool addition to 0.5 g/l. Chemical properties were determined two weeks after the application of soluble pre-plant fertilizers.

Substrates were tested in the experiments with following perennials: *Salvia nemorosa* cv. Tesqui-

Table 1. Physical properties of components and substrates

Component substrate	PS	AS	CC	5 kPa	EAW	WBC	DAW	DBD	PD	OM
	(% volume)							(g/l)	(g/cm^3)	(%)
Compost	73.0	7.6	65.4	41.8	23.6	0.8	41.0	556	2.06	37.3
Bark	82.3	27.5	54.9	39.4	15.5	1.4	38.0	328	1.86	56.3
Rockwool	95.2	21.2	74.0	7.3	66.7	0.5	6.8	122	2.55	2.3
P	93.4	6.8	86.7	44.0	42.7	2.6	41.5	105	1.60	85.0
PR	92.9	10.0	82.9	37.2	45.7	1.0	36.2	131	1.85	61.3
C	90.5	11.2	79.4	42.4	37.0	1.2	41.2	190	2.00	61.4
CR	87.9	11.1	76.8	39.1	37.7	1.3	37.8	247	2.04	45.6
B	87.9	11.7	76.2	41.9	34.3	1.3	40.6	214	1.77	66.3
BR	86.8	15.9	70.9	38.6	32.3	2.5	36.2	249	1.88	56.7

PS – porosity calculated from dry bulk density (DBD, EN 13 041) and particle density (PD), AS – air space at 1 kPa suction, CC – container capacity, water content at 1 kPa suction, 5 kPa – content of water at 5 kPa suction, EAW – easily available water (difference between water content at 1 and 5 kPa suction), WBC – water buffering capacity (difference between water content at 5 and 10 kPa suction), DAW – difficult available water (water content at 10 kPa suction), OM – content of organic matter cola, *Erigeron speciosus* cv. Rosa Juwel, *Veronica incana, Veronica porphyriana*, and *Lychnis viscaria* cv. Atropurpurea. The seedlings were grown in the greenhouse. Sowing was done at the end of March and the seedlings were transplanted into plug trays with peat substrate in the middle of April. The plants were planted into containers 8 × 8 × 9 cm (volume 400 cm^3) at the end of May and were cultivated outdoor. Sprinkler irrigation was used. Plants were fertilized at three-week intervals by 0.2% NPK fertilizer solution, three times in June and July with the fertilizer containing 19% N, 6% P_2O_5, 20% K_2O and twice in July and August with the fertilizer containing 15% N, 5% P_2O_5, 30% K_2O.

Each variant (type of substrate) had 5 replications with 16 plants in each. Fresh weight of the plants was measured. The plants in each replication were divided into halves; the first half was evaluated at the period 4–5 weeks after planting, the second at the period 10–14 weeks after planting, when the plants were marketable. All the data sets were tested for normality and analyzed by ANOVA and Duncan's multiple range test.

RESULTS AND DISCUSSION

Components prepared from waste materials had different physical properties in comparison with peat (var. P) (Table 1, Fig. 1). Compost and bark had higher dry bulk density (DBD), lower porosity, container (water) capacity (CC) and especially content of easy available water (EAW). Bark had higher air space (AS). Crushed rockwool had higher porosity, AS and EAW than peat, but very low DAW, these results are in agreement with those of Fonteno (1996). Tested crushed rockwool had higher density than samples tested by Bougoul et al. (2005), but porosity, CC, shape of retention curves, were similar to sample with the density of 67 g/l.

Peat substrate P had the highest porosity and CC and the lowest AS. It had relatively high content of EAW. The application of rockwool to the peat substrate (var. PR) moderately increased EAW and decreased CC and difficult available water (DAW). Addition of rockwool to peat substrate changed the shape of retention curve (Fig. 2). Similar results of available water content in peat substrates with rockwool were reported by Heiskanen (1995). On the other hand using recycled crushed rockwool (Riga et al. 2003) substantially increased AS and slightly decreased EAW in mixtures with 40% vol. of rockwool.

The addition of compost (25% vol.) or bark (40% vol.) to peat substrate decreased porosity and increased AS; CC and EAW were thus lower and DAW was at the same level as in peat substrate.

Peat replacement by rockwool in substrate with compost (var. CR) slightly decreased porosity, CC, and DAW, content of EAW was the same as in the substrate without rockwool (Table 1, Fig. 2). Peat replacement by rockwool in substrate with bark (var. BR) slightly decreased porosity and increased AS, and so there was a relatively high reduction of CC; in this case addition of rockwool also decreased EAW. Substrate BR had the lowest EAW of all tested substrates. Peat replacement by rockwool increased dry bulk density and decreased organic matter content in all mixtures.

The composition of substrates influenced their chemical properties (Table 2). The compost had very high content of available K, high content of available P and low content of available nitrogen. Both compost and composted bark had slightly alkaline reaction and relatively high content of available Ca. The

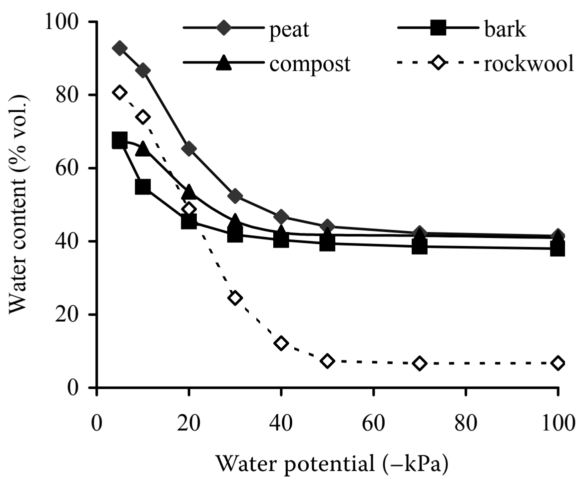

Fig. 1. Moisture retention curves for the components

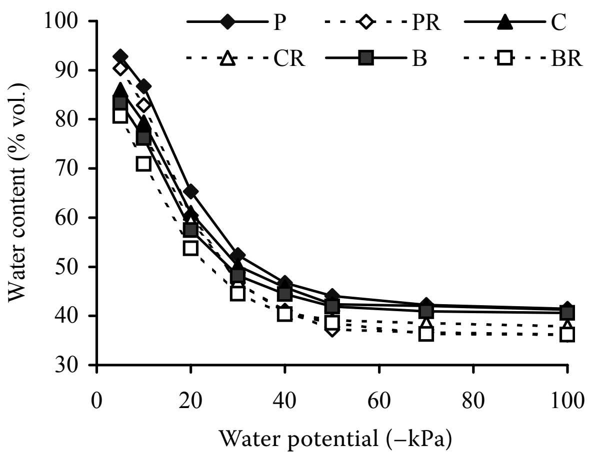

Fig. 2. Moisture retention curves for the substrates

Table 2. Chemical properties of components and substrates, pH, EC and available Ca in water extract, content of available nutrients in CAT extract – optimum range for organic substrates (Alt 1994)

Component substrate	pH	EC (mS/cm)	N-NH_4	N-NO_3	P	K	Mg	Ca
			(mg/l)					
Peat	4.0	0.05	72	12	5	12	73	11
Compost	8.2	0.91	53	109	62	1,951	79	88
Bark	8.0	0.17	44	11	6	166	86	64
Rockwool	6.5	0.05	25	8	3	30	49	25
P	6.0	0.25	131	46	37	112	137	33
PR	5.9	0.30	149	54	32	170	119	49
C	6.1	0.31	131	62	55	411	121	37
CR	6.7	0.40	156	70	55	573	126	42
B	6.5	0.46	99	60	31	178	99	48
BR	6.9	0.38	98	69	32	195	125	53
Optimum	5.5–6.5	0.2–0.5	sum N 80–200		20–40	80–220	50–100	40–100

bark had relatively low content of available potassium in comparison with the standard range of 300 to 500 mg/l (Dubský, Šrámek 2007). Rockwool had a slightly acid reaction and low EC value and content of available nutrients. The final dosage of fertilizers and limestone was based on these results.

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 high electric conductivity (EC). Content of available nutrients in peat and peat-bark substrates was in optimum range. The peat replacement by rockwool increased the content of available K in all types of substrates, especially in the substrate with compost, and increased pH value in substrates with alternative components.

Good growth of all tested perennials was found in the peat substrate P (Table 3). The peat replacement by rockwool in peat substrate had no or very small non-significant effect on plant growth (*Erigeron, Veronica incana*). Similar results with pot plants in peat substrate with 20 or 40% vol. of rockwool were reported by Riga et al. (2003), only high content of rockwool (60% vol.) resulted in inadequate plant quality for market.

Good results were obtained also in substrate C with compost, especially with perennials with higher demands for nutrients (*Salvia, Erigeron).* Growth of other species was slightly suppressed in substrate amended with 25% vol. of compost, Wilson et al. (2002) reported similar results.

Addition of rockwool to this substrate (var. CR) significantly decreased only the growth of *Erigeron*. The worst results were obtained in substrates B and BR with bark, which had low content of EAW. Replacement of peat by rockwool in peat-bark substrate significantly decreased the growth of *Salvia*, substrate BR had the lowest EAW of all tested substrates. In other cases the differences among substrates B and BR were not significant. Similar results were obtained with evaluating two factors of substrates composition, rockwool addition and type of substrate according to organic components (Table 4).

Generally the best growth of perennials was found in peat substrates, pure peat substrate or in substrate with the addition of rockwool. These results are in agreement with the other experiments with perennials (Dubský, Šrámek 2008). In substrates with compost the content of soluble salts and the content of available potassium are limiting. Content of available potassium up to 600 mg/l of substrate is acceptable in these substrates. In the substrates with bark the low content of EAW is limiting. In spite of these properties perennials in substrates with alternative organic components had good market value.

The peat replacement by rockwool in substrates with alternative organic components decreased the plant growth in most cases. The addition of rockwool decreased CC of the substrates, especially the content of DAW.

The results of the experiments revealed that in used types of substrates it is possible to replace peat by crushed hydrophilic rockwool up to 35% vol. without making the quality of substrates and the plant growth substantially worse.

Table 3. Results of one-way ANOVA, fresh weight (g) of one plant, date of evaluation

Variant	*Salvia nemorosa*		*Erigeron speciosus*		*Veronica incana*		*Veronica porphyriana*		*Lychnis viscaria*	
	21. 6.	29. 7.	21. 6.	16. 8.	4. 7.	30. 8.	4. 7.	30. 8.	4. 7.	30. 8.
P	89.6 ab	168.2 a	36.9 a	80.0 a	37.2 a	49.4 a	39.3 a	36.5 ab	65.6 ab	126.0 a
PR	93.0 a	163.5 a	30.7 ab	67.0 ab	39.7 a	42.3 ab	35.4 ab	38.6 a	63.0 ab	127.6 a
C	87.4 ab	177.2 a	33.1 ab	67.9 ab	23.7 b	31.8 c	28.5 b	36.3 ab	59.0 ab	125.5 a
CR	79.7 b	163.2 a	23.3 c	48.6 bc	24.0 b	33.7 bc	16.4 c	25.6 bc	53.2 ab	102.0 ab
B	53.1 c	125.1 b	11.3 d	30.8 c	23.1 b	23.9 c	17.2 c	32.3 abc	46.8 b	72.6 b
BR	32.2 e	79.0 c	9.1 d	38.5 c	16.9 b	21.4 c	14.6 c	23.2 c	42.8 b	78.1 b

Means followed by the same letter in the same column are not significantly different according to the Duncan's multiple range test, $P < 0.05$

Table 4. Results of two-way ANOVA, fresh weight (g) of one plant, evaluation of the factors: addition of rockwool (0 – none, R – 35% vol.), type of substrate (P – peat-based, C – with compost, B – with bark), date of evaluation

Factor	*Salvia nemorosa*		*Erigeron speciosus*		*Veronica incana*		*Veronica porphyriana*		*Lychnis viscaria*	
	21. 6.	29. 7.	21. 6.	16. 8.	4. 7.	30. 8.	4. 7.	30. 8.	4. 7.	30. 8.
0	76.7 a	156.8 a	27.1 a	58.7 a	28.0 a	35.0 a	28.3 a	35.0 a	57.1 a	108.0 a
R	68.3 a	135.2 a	21.1 a	50.3 a	26.9 a	32.5 a	22.1 a	29.1 a	53.0 a	102.6 a
P	83.6 a	165.9 a	33.8 a	73.5 a	38.4 a	45.8 a	37.3 a	37.5 a	64.3 a	126.8 a
C	91.3 a	170.2 a	28.2 b	57.0 b	23.8 b	32.8 b	22.4 b	30.9 ab	56.1 ab	113.7 a
B	42.7 b	102.0 b	10.2 c	33.0 c	20.0 b	22.7 c	15.9 b	27.8 b	44.8 b	75.4 b

Means followed by the same letter in the same column within one factor are not significantly different according to the Duncan's multiple range test, $P < 0.05$

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Vliv minerální plsti na fyzikální vlastnosti pěstebních substrátů pro trvalky

ABSTRAKT: V pokusu s trvalkami v kontejnerech byla ověřena možnost náhrady rašeliny v pěstebních substrátech drcenou hydrofilní minerální plstí. Byly porovnány tři typy substrátů, rašelinový a dvě směsi rašeliny s alternativními komponenty – kompostem (25 % obj.) nebo kompostovanou smrkovou kůrou (40 % obj.). Pro stanovení retenčních křivek a dalších fyzikálních vlastností komponentů a substrátů byl použit pískový tank v rozsahu –0,5 až –10 kPa. Přídavek plsti do rašelinového substrátu zvýšil obsah vzduchu a obsah lehce dostupné vody a neovlivnil růst rostlin. Rostliny v substrátech s alternativními organickými komponenty byly menšího vzrůstu, měly ale dobrou tržní kvalitu. Přídavek plsti do těchto substrátů neměl průkazný efekt. Drcená minerální plst v množství 35 % obj. může nahradit rašelinu v rašelinových substrátech i ve směsích s alternativními komponenty bez výrazného zhoršení kvality substrátu i růstu rostlin.

Klíčová slova: rašelina; alternativní organické komponenty; drcená minerální plst; retenční křivky; trvalky

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