ACTA AGROBOTANICA
Vol. 55, z. 2 – 2002
s. 57–64

The effect of growing media and concentration of nutrient solution on growth, flowering and macroelement content of media and leaves of *Tymophylla tenuiloba* Small.

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(Received: 8.04.2002)

Summary

Effects of growing media and concentration of nutrient solution on growth, flowering, evapotranspiration and macroelement content of media and leaves of *Tymophylla tenuiloba* were evaluated under ebb-and-flow conditions. Two media: peat and peat + perlite (3 : 1, v/v), and four concentrations of nutrient solution: 1.0, 1.5, 2.0, 2.5 mS cm^{-1} were applied. High quality plants were produced in both media and all concentration of nutrient solution. The lowest evapotranspiration was measured at the highest concentration of nutrient solution. N concentration of leaves was high in all treatments. Concentrations of K, Ca, and Mg decreased with increasing concentration of nutrient solution. Opposite was found for P. At the end of cultivation the lowest pH was measured in the upper layer of growing media. The highest total soluble salt level was measured in the upper layers. Upper layers accumulated more N-NO_3, P, Ca, and Mg. Mineral element content of both media was high in all concentrations of nutrient solution. Low concentration of nutrient solution at 1.0 mS cm^{-1} is recommended, although *Tymophylla tenuiloba* can be also cultivated at higher concentrations of nutrient solution up to 2.5mS cm^{-1}, if placed on the same bench with other bedding plants requiring more nutrients.

Key words: *Tymophylla tenuiloba* Small., ebb-and-flow, potting media, fertigation, mineral element content, growth, flowering, evapotranspiration

INTRODUCTION

Tymophylla tenuiloba, known as a Dahlberg daisy, belongs to the *Asteraceae* (Armitage, 2001). This fine leafed annual grows to 20–30 cm with extremely thin leaves and tiny yellow flowers. A native of Texas and Mexico is used as bedding or pot plant. It can be also planted in rock gardens.

Ebb-and-flow irrigation system saves labor, water and fertilizers and is widely used for production of flowering plants in small containers (Molitor, 1990). A large number of different bedding plant species are usually grouped on this same bench on the basis of the similarity of their water and nutrient requirements. Little information is available on cultural requirements of *Tymophylla tenuiloba*. This experiment was designed to characterize some of the major parameters for cultivation of this plant in ebb-and-flow system, including composition of growing medium and concentration of nutrient solution. The effect of these two factors on macroelement content of leaves, chemical characteristic of growing medium, and evapotranspiration was also analyzed.

MATERIAL AND METHODS

The Dahlberg daisy seeds (*Tymophylla tenuiloba* Small., syn. *Dyssodia tenuiloba* Robins.) was sown in peat + sand (6 : 1, v/v) medium, adjusted to pH 6.0 with $CaCO_3$. The sowing date was March 13, 2001. The seedlings were pinched once at 6-leaf stage. The seedlings were transplanted to 10-cm-wide pots in May 21. The potting media were: 1) sphagnum peat based growing medium, and 2) the same peat + perlite (3 : 1, v/v). Before planting potting media were amended with 1 g dm^{-3} commercially available fertilizer (13.6 N : 2.8 P : 15.0 K : 9.0 Ca : 2.7 Mg plus microelements, Azofoska, Poland), pH was adjusted to 6.0 with $CaCO_3$, EC about 0.6 mS cm^{-1} (medium : H_2O = 1 : 2, v/v). Plants were fertigated by subirrigation (ebb-and-flow benches, Clauhan Project A/S, Denmark). Commercially available fertilizer Symfovita A (12.5 N – 2.1 P – 18.5 K – 2.9 Mg – 0.025 B – 0.025 Zn – 0.0005 Co – 0.1 Mn – 0.02 Cu – 0.003 Mo) was used for preparation of nutrient solution. EC (electrical conductivity) of nutrient solutions were: 1.0, 1.5, 2.0, and 2.5 mS cm^{-1}, and pH 6.5, irrespectively of the EC treatment. Macroelement contents of nutrient solutions were: EC 1.0 82 N, 20 P, 97 K, 90 Ca and 26 Mg; EC 1.5 119 N, 25 P, 190 K, 85 Ca, and 39 Mg; EC 2.0 162 N, 37 P, 299 K, 79 Ca, and 53 Mg; EC 2.5 204 N, 49 P, 394 K, 74 Ca, and 64 Mg (in mg dm^{-1}). The irrigation frequency was one every 2 days or one per day, depending on size of plants and solar radiation. After the fertigation the surplus of nutrient solution was always led back to the reservoir. Fresh nutrient solution was added to the reservoir weekly. There were four sections of benches fertigated separately. The greenhouse environment was maintained at 25° /18° C (day/night) temperature.

Evapotranspiration (EVPT) was determined by weighing plants with pots. There were 8 uniform plants randomly sampled from each treatment for this purpose. Plants were weighed in the morning, about 30 minutes after irrigation (when the excess of water drained out), and the day after, just before irrigation. The determinations of EVPT were made at 2 growth stages: visible flower buds and full flowering.

All growth parameters were determined at the beginning of flowering, about 4 weeks after planting (June 21, 2001). All plants were measured. Leaf dry weight and leaf-tissue nutrient contents were determined on 3 plants per replicate. There were 3 replications per treatment. The youngest, fully expanded leaves were used. The leaf tissue were oven-dried at 78° C, milled to homogenous samples, and then treated with the mixture of HNO_3 and $HClO_4$. The concentrations of K, Ca, and Mg were measured using atomic absorption spectrophotometry (PU 9100X; Philips, Holland), N was determined using Kjeldahl method with automatic distillation system with boric acid (Kieltec, Tecator, Sweden), and P was determined colorimetrically by using vanadium-molybdate complex.

All medium was removed from each pot and separated horizontally into 3 samples: upper, middle and bottom. Available macroelements contained in each medium sample were extracted with acetic acid using modified Spurway method (Nowosielski, 1989). The concentrations of K, Ca, Mg, and P were determined as described above for leaf samples. N-NO_3 was measured with a nitrate-specific electrode, N-NH_4 with an ammonium-specific electrode (Orion, Cambridge, Massachusetts, USA). EC was determined by a conductivity meter (Type OK-1021, Badelkis, Budapest, Hungary).

The experiment employed a split-plot factorial design with 2 potting media and 4 concentrations of nutrient solution. There were 20 pots per treatment, each plant was treated as a replication. The treatments were statistically analyzed by analysis of variance and means were compared with Duncan's multiple range test at 95% level of significance.

RESULTS AND DISCUSSION

High quality plants of *Tymophylla tenuiloba* with no foliar deficiency or toxicity symptoms were produced in both media and all concentrations of nutrient solution (Table 1). The plants grown in peat had higher fresh and dry weights and more flower buds and flowers. The effect of growing media on plant height and shoot number was negligible. The time of flowering was only slightly affected by applied treatments. The plants grown at higher concentration of nutrient solution had lower fresh weight and were slightly higher than those grown at lowest concentration of 1.0 mS cm^{-1}. There was no effect of concentration of nutrient solution on flower bud and flower numbers.

Table 1
The effect of growing medium and concentration of nutrient solution (EC) on growth and flowering of *Tymophylla tenuiloba*.

Medium	EC $mS\ cm^{-1}$	Fresh weight (g/plant)	Dry weight (g/plant)	Plant height (cm)	Shoot number per plant	Number of days from planting to flowering	Flower bud number per plant	Flower number per plant
Peat	1.0	32.9 d	5.1 d	27.4 a	18 ab	27 ab	22 bcd	11 bc
	1.5	27.3 c	4.4 cd	28.4 ab	18 ab	26 ab	23 d	11 bc
	2.0	24.5 bc	4.3 bcd	28.6 abc	20 b	25 a	22 cd	13 c
	2.5	22.3 ab	4.0 abc	29.7 bc	15 a	28 b	18 ab	10 abc
Peat + perlite 3:1	1.0	25.6 bc	3.9 abc	28.2 ab	16 a	26 ab	16 a	9 ab
	1.5	21.6 ab	3.3 a	29.4 bc	17 a	26 ab	14 a	7 a
	2.0	21.3 ab	3.5 ab	30.2 c	17 a	27 ab	19 abc	10 abc
	2.5	19.2 a	3.4 ab	30.2 c	15 a	26 ab	18 ab	10 abc
Significance								
Medium		xxx	xxx	xx	xx	ns	xxx	xxx
EC		xxx	xx	xxx	xx	ns	ns	ns
Medium x EC		ns	ns	ns	ns	xx	xx	ns

Within columns, values followed by the same letter(s) are not significantly different at P=0.05; ns, *, **, *** nonsignificant or significant at P=0.1, 0.05, 0.01, respectively.

EVPT is dependent upon many factors, either plant related and environmental (Baille et al. 1994ab, Stanghellini and Meurs, 1989). Daily EVPT of *T. tenuiloba* determined at the visible flower bud stage and full flowering, as affected by media and concentration of nutrient solution is presented in Table 2. At visible flower bud stage EVPT was low. Slightly higher EVTP was measured in peat than in peat + perlite. At this stage of development EVPT was not affected by concentration of nutrient solution. At full flowering EVPT was almost 3 times higher than at visible flower bud stage. The lowest EVPT was measured at the highest concentration of nutrient solution. Similar effect of concentration of nutrient solution on transpiration of *Begonia x hiemalis* Fotsch was earlier observed (Mortensen and Gislerod, 1989). EVTP data can be used for counting water consumption during cultivation of *T. tenuiloba* on ebb-and-flow benches.

N concentration of *T. tenuiloba* leaves was high, over 4% d.w. in all treatments (Table 3). N concentration of leaves of plants grown in peat slightly decreased with increasing concentration of nutrient solution. Opposite was found for plants grown in peat + perlite, although differences were rather small. Plants grown in peat accumulated more P and Mg than those grown in peat + perlite. The effect of growing media on other mineral element concentrations of leaves was negligible. Lower contents of K, Ca, and Mg were measured in leaves of plants grown at high concentration of nutrient solution, comparing to plants grown at low concentration. P concentration of leaves of *T. tenuiloba* grown in both media increased with increasing concentration of nutrient solution.

Table 2

The effect of growing medium and concentration of nutrient solution on evapotranspiration of *Tymophylla tenuiloba*.

Treatments	EVPT at visible flower bud (g/plant)	EVPT at full flowering (g/plant)
Medium		
Peat	25.9 b	67.8 b
Peat+perlite 3:1	22.1 a	61.6 a
EC		
1.0 mS cm $^{-1}$	24.2 a	65.3 b
1.5 mS cm $^{-1}$	22.0 a	66.3 b
2.0 mS cm $^{-1}$	26.0 a	75.2 c
2.5 mS cm $^{-1}$	23.8 a	52.0 a
Significance		
Medium	xx	xx
EC	ns	xxx
Medium x EC	ns	ns

For explanations see Table 1.

Data are averages over 2 potting media and 4 concentrations of nutrient solution, respectively.

Table 3

The effect of growing medium and concentration of nutrient solution on mineral element content (% dry weight) of leaves of *Tymophylla tenuiloba*.

Medium	EC mS cm $^{-1}$	N	P	K	Ca	Mg
		% dry weight				
Peat	1.0	4.72 d	0.13 b	4.18 bcd	0.56 e	0.31 d
	1.5	4.41 b	0.16 c	4.20 cd	0.34 bc	0.24 c
	2.0	4.51 bc	0.13 b	3.65 a	0.28 a	0.25 c
	2.5	4.39 b	0.16 c	3.66 ab	0.31 ab	0.20 ab
Peat + perlite 3:1	1.0	4.20 a	0.10 a	3.89 abcd	0.39 d	0.21 b
	1.5	4.41 b	0,13 b	4.38 d	0.36 cd	0.25 c
	2.0	4.42 b	0.12 b	3.68 abc	0.34 bc	0.18 a
	2.5	4.64 c	0.16 c	3.61 a	0.28 a	0.19 ab
Significance						
Medium		xx	xxx	ns	xx	xxx
EC		ns	xxx	xxx	xxx	xxx
Medium x EC		xxx	xxx	ns	xxx	xxx

For explanations see Table 1.

Table 4

The effect of growing media and concentration of nutrient solution on total soluble salts (T.S.S., g KCl dm^{-3}), pH and mineral nutrient content (mg dm^{-3}) in different layers of growing media after cultivation of *Tymophylla tenuiloba* on ebb-and-flow benches.

Media	EC mS cm^{-1}	Layers	pH	T.S.S. g KCl dm^{-1}	N-NO_3	N-NH_4	P	K	Ca	Mg
					mg dm^{-3}					
Peat	1.0	Upper	4.3 c	2.54 g	217 c	3 ab	52 e	114 ab	1321 efg	179 abc
		Middle	5.0 kl	0.93 b	61 ab	2 a	15 a	76 a	1091 cd	160 ab
		Bottom	5.8 g	0.76 a	18 a	4 b	10 a	156 b	1006 abc	150 a
	1.5	Upper	4.0 a	3.46 i	431 f	8 de	58 ef	345 d	1640 i	200 cd
		Middle	4.5 de	2.27 f	284 de	6 c	38 c	295 cd	1258 defg	172 abc
		Bottom	5.0 l	1.93 d	248 cd	10 e	45 d	426 e	1124 cd	188 bcd
	2.0	Upper	4.1 b	5.38 n	917 j	21 i	134 l	717 gh	1634 i	274 fg
		Middle	4.5 hij	3.85 j	603 g	17 g	71 g	668 fg	1325 efg	262 fg
		Bottom	4.9 ij	2.61 g	448 f	19 h	92 i	767 h	1011 abc	242 ef
	2.5	Upper	4.6 ef	5.33 n	1027 k	50 l	164 n	910 i	1645 i	316 hi
		Middle	4.7 fg	4.08 k	783 i	33 jk	116 k	892 i	1191 cde	267 fg
		Bottom	4.8 ghi	3.06 h	578 g	32 j	105 j	900 i	893 ab	255 f
Peat+ perlite 3:1	1.0	Upper	4.5 d	2.55 g	310 e	6 c	62 f	166 b	1426 fgh	186 bc
		Middle	4.7 fgh	0.85 ab	61 b	2 ab	10 a	63 a	995 abc	161 ab
		Bottom	5.6 o	0.81 ab	72 b	3 ab	10 a	140 b	1005 abc	187 bcd
	1.5	Upper	4.8 hij	4.03 k	445 f	7 cd	59 f	337 d	1447 gh	264 fg
		Middle	5.2 m	2.10 e	244 cd	6 c	23 b	274 c	1162 cde	219 de
		Bottom	5.3 n	1.70 c	235 cd	9 e	45 d	429 e	1042 bc	204 cd
	2.0	Upper	4.0 a	4.36 l	808 i	16 g	112 k	703 fg	1644 i	309 hi
		Middle	4.9 jk	3.06 h	443 f	13 f	85 h	657 f	1238 def	292 gh
		Bottom	4.9 ij	2.55 g	415 f	17 g	110 jk	711 fgh	994 abc	244 ef
	2.5	Upper	4.5 d	5.95 o	964 j	33 jk	144 m	905 i	1559 hi	338 i
		Middle	4.8 hij	4.53 m	703 h	33 jk	114 k	944 i	1132 cde	321 hi
		Bottom	5.0 kl	3.46 i	553 g	35 k	105 j	910 i	829 a	270 fg
Significance										
Medium			xxx	ns	xxx	xxx	xx	ns	xx	xxx
EC			xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Medium x EC			xxx	xxx	xxx	xxx	xxx	ns	ns	ns
Layers			xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Medium x layers			xxx	xxx	xxx	xxx	xxx	ns	ns	ns
EC x layers			xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Medium x EC x layers			xxx	xxx	ns	xxx	xxx	ns	ns	xx

For explanations see Table 1.

Table 3 summarizes data on the chemical composition of growing media after 4 weeks of culture. The pH of both media was lower than before planting, probably due to the presence of N-NH4 in nutrient solution. The lowest pH was measured in upper layer of growing medium. The highest total soluble salts was found in upper layers of both media, as previously reported by other authors (Guttormsen, 1969;

Molitor, 1990). Higher concentration of nutrient solution increased the TSS content, as well as N, P, and K content of both media. Interactions between all factors tested for pH and TSS were observed. Elevated salt concentration in upper layer of medium is due to evaporation of water from the potting medium surface and lack of leaching in ebb-and-flow system (Molitor, 1990). Upper layers of both media accumulated more N-NO_3, P, Ca, and Mg. Potassium content was higher in upper and bottom layers than in the middle layers. The salts accumulating in upper layer of medium are generally not a problem when plants grown on ebb-and-flow benches receive low fertilizer concentration (Nelson, 1991; Dole et al. 1994). Root system is usually located in the middle and bottom layers (Fonteno et al. 1981; Kent and Reed, 1996).

Mineral element content of both media fertilized with nutrient solution at 1.5 – 2.5 mS cm^{-1} was high. The lowest concentration of nutrient solution at 1.0 mS cm^{-1} ensured very good growth and flowering of *T. tenuiloba* and such low concentration should be recommended for cultivation of this plant on ebb-and-flow benches. Low concentration of nutrient solution offers some advantages: freedom from antagonistic interactions between nutrients during fertilizer uptake by the plants, avoidance of excessive tissue levels, lower accumulation of salts in growing medium and lower rise in salt concentration during water stress conditions, especially during postproduction phase (Nelson, 1994).

CONCLUSIONS

1. Nutrient solution at EC 1.0 mS cm^{-1}, pH 6.5, containing (in mg dm^{-1}): 82 N, 20 P, 97 K, 90 Ca and 26 Mg plus microelements ensures very good growth and flowering of *T. tenuiloba* cultivated on ebb-and-flow benches.
2. *T. tenuiloba* can be also cultivated at higher concentrations of nutrient solution up to 2.5 mS cm^{-1}, if placed on the same bench together with other plants requiring more nutrients.

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Wpływ podłoży i stężeń pożywki na wzrost, kwitnienie, ewapotranspirację i zawartość makroelementów w podłożach i w liściach *Tymophylla tenuiloba* Small.

Streszczenie

Badano wpływ podłoży i stężeń pożywki na wzrost, kwitnienie, ewapotranspirację i zawartość makroelementów w podłożach i w liściach *Tymophylla tenuiloba*, uprawianej na stołach zalewowych. Rośliny posadzono w dwóch podłożach: torfie i torfie z perlitem (3 : 1, v/v). Zastosowano cztery stężenia pożywki nawozowej: 1,0, 1,5, 2,0 2,5 mS cm^{-1}, pH pożywek wynosiło 6.5, niezależnie od EC. Pożywki sporządzono z gotowego nawozu sypkiego Symfovita A (12.5 N – 2.1 P – 18.5 K – 2.9 Mg – 0.025 B – 0.025 Zn – 0.0005 Co – 0.1 Mn – 0.02 Cu – 0.003 Mo). Jakość wszystkich otrzymanych roślin była wysoka, niezależnie od traktowania. Najniższą ewapotranspirację mierzono u roślin nawożonych pożywką najbardziej stężoną. Zawartość N w liściach była wysoka u wszystkich roślin. Zawartość K, Ca i Mg zmniejszała się wraz ze wzrostem stężenia pożywki, natomiast zawartość P zwiększała się. Po zakończeniu uprawy najniższe pH mierzono w górnej wartswie podłoża w doniczce. Najwyższe zasolenie występowało w warstwie górnej. W warstwie górnej akumulowały się N-NO_3, P, Ca i Mg. Zawartość makroelementów w obu podłożach była wysoka, niezależnie od stężenia pożywki. Poleca się nawożenie tymofili uprawianej na stołach zalewowych pożywką o stężeniu 1,0 mS cm^{-1}. Można ją także nawozić pożywkami o wyższym stężeniu do 2,5 mS cm^{-1}, jeżeli uprawiana jest na tym samym stole z roślinami o wyższych wymaganiach pokarmowych.