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Growing Medium and Fertilization Regime Influence Growth and Essential Oil Content of Rosemary

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Abstract. **Plants of rosemary [*Rosmarinus officinalis* L. (Lamiaceae)] were grown in pots containing a soilless (1 sphagnum peat :1 perlite) or soil-based (1 sphagnum peat : 1 perlite :1 field soil) growing medium and fertilized with either 12N-5.2P-12.5K controlled-release fertilizer (CRF) at 9.0 g/pot; constant liquid fertilization (LF) with 20N4.3P-16.7K at 150 mg N/liter; constant LF at 150 mg N/liter, plus CRF at 4.5 g/pot; weekly LF at 150 mg N/liter; or weekly LF at 150 mg N/liter, plus CRF at 4.5 g/pot. Constant LF plus CRF generally reduced plant height and depressed shoot fresh weight relative to other fertilizer regimes. Essential oil content was highest in plants receiving weekly LF. Plants grown in the soil-based mix were shorter, shoot fresh and dry weight tended to be lower, and essential oil yield was higher when compared to plants grown in the soilless mix. Satisfactory growth was obtained in both media when rosemary plants were fertilized with 12N-5.2P-12.5K CRF at 9.0 g/pot or weekly LF with 20N<.3P-16.7K at 150 mg N/liter.**

Rosemary is an evergreen, perennial shrub that is endemic to the Mediterranean region and has been cultivated since ancient times (Simon et al., 1984). The aromatic, resinous leaves are used for culinary flavoring, and oil distilled from leaves and flowering shoots is used in perfumery and medicine (Liberty Hyde Bailey Hortorium, 1976). Rosemary shows commercial potential as a dual-purpose foliage and culinary potted plant (DeBaggio and Boyle, 1988). Marketable-size potted plants can be produced in 4 to 6 months from propagation by cuttings (DeBaggio, 1987).

Research to determine the influence of growing media and fertilization on the growth and essential oil content of aromatic herbs appears to be lacking. We are unaware of any reports on the effect of growing media or fertilization practices on growth of rosemary under protected cultivation (Simon et al., 1984). The following experiment was initiated to determine the influence of growing media and fertilization regimes on the growth and essential oil content of potted rosemary.

Shoot-tip cuttings (7.5 to 10 cm long) were propagated under intermittent mist on 8 June 1987. The propagation medium was a 1:1 (v/v) combination of Pro-Mix BX (Premier Brands, New Rochelle, N.Y.) and perlite maintained at 21 to 24C by bottom heat. On 29 June, rooted cuttings were pruned by removing ≈1 cm of the shoot apices; then plants were potted in 0.14-liter plastic containers (one plant per pot) using Pro-Mix BX. Plants were fertilized one to three times weekly with 20N-4.3P-16.7K at 150 mg N/liter from 7 July to 28 Aug. Plants were transplanted on 28 Aug. into 1.90-liter plastic pots (one plant per pot) filled with either a soilless [1 sphagnum peat :1 perlite (v/v)] or soil-based [1 sphagnum peat :1 perlite :1 field soil (by volume)] growing medium. The field soil was a coarse-loamy, mixed, mesic Typic Fragiochrept that was steam-pasteurized (≈80 C minimum for 30 rein) before mixing. Both media were amended with 5.93 kg dolomitic limestone/m^3. On 29 Aug., plants were pruned as described above and fertilization regimes were initiated. The fertilization regimes were: 1) Sierra 12N-5.2P-12.5K (Sierra Chemical, Milpitas, Calif.) controlled-release fertilizer (CRF) at 9.0 g/pot; 2) liquid fertilization (LF) using Peters 20N-4.3P-16.7K (Peters Fertilizer Products, Fogelsville, Pa.) applied at 150 mg N/liter at every watering; 3) LF applied at every watering at 150 mg N/liter plus CRF at 4.5 g/pot; 4) LF once each week at 150 mg N/liter; 5) or LF once each week at 150 mg N/liter, plus CRF at 4.5 g/pot. CRF was applied as a one-time top dressing at the start of the experiment. A 1:100 fertilizer injector was used for LF applications. Pots were spaced on 25-cm centers from the start of the fertilization regimes until harvest. There were eight replications (pots) per treatment and treatments were completely randomized on the greenhouse bench.

Plants were grown in a glasshouse at the Univ. of Massachusetts, Amherst (42° 22.5' N latitude). Glasshouse temperature setpoints were 18/24C (night temperature/vent) during the experiment; the temperatures ranged from 16 to 39C. Plants were watered one to three times weekly during the experiment to maintain adequate moisture in the growing media.

Bulk density and cation-exchange capacity were determined for both growing media using standard procedures (Blake, 1965; Chapman, 1965). Extracts of a 1 growing medium : 2 deionized water (v/v) mixture were used for soluble salt and pH tests (Peterson, 1982). Porosity measurements were obtained using 4-cm-diameter glass columns filled with 14 cm of growing medium. Total porosity was defined as the ratio of the saturated medium water volume to the growing medium volume (x 100). Maximum water capacity was defined as the ratio of the drained medium water volume to the growing medium volume (x 100). Aeration porosity was defined as the difference between total porosity and maximum water capacity. Physical and chemical analyses were performed at the experiment initiation using five replicate samples of each growing medium per analysis.

Plants were harvested on 3 Dec., and data were collected on plant height (base of plant to apex of longest shoot) and shoot fresh weight. Shoots were dried to constant weight (40C for 7 days) and then reweighed. Foliage was removed from each replicate plant, and tissue samples were ground to pass a 20-mesh screen. Essential oils were extracted from tissue samples (35 to 65 g) by hydrodistillation for 1 hr with a modified clevenger trap (ASTA, 1968).

Physical and chemical properties of the two growing media differed significantly (Table 1). Bulk density, cation exchange capacity, maximum water capacity, pH, and soluble salt content were greater for the soil-based mix compared to the soilless mix. Total and aeration porosity were considerably higher in the soilless mix than in the soil-based mix.

Fertilization practices had a significant effect on plant height and fresh weight of rosemary (Table 2). Plants receiving constant LF plus CRF were shorter than plants under any other fertilization regime, except for CRF only. In addition, constant LF plus CRF depressed shoot fresh weight relative to other fertilizer treatments. Constant LF plus CRF tended to reduce dry matter accumulation compared to other fertilization regimes, although not significantly, (≈12 vs. 14 to 16 g). Bell and Coorts (1979) observed that lemon balm *(Melissa oficinalis),* peppermint *(Mentha × piperata),* and sage *(Salvia officinalis)* plants that were fertilized weekly with 20N-8.7P-16.7K at 300 mg N/liter were taller and higher in fresh and dry weight than plants fertilized weekly with 20N-8.7P-16.7K at either 50, 100, or 200 mg N/liter. In our study, rosemary plants were shortest and lowest in fresh weight at the highest fertilization rate (constant LF plus CRF), suggesting that this rate of fertilization suppressed

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Table 1. Chemical and physical characteristics of growing media used for production of *Rosmarinus officinalis.*

Medium	pH	Conductivity ($dS \cdot m^{-1}$)	Bulk density ($g \cdot cm^{-3}$)	Cation exchange capacity (meq/100 cm^3)	Total porosity (% vol)	Aeration porosity (% vol)	Maximum water capacity[z] (% vol)
Peat : perlite	5.9	0.09	0.11	4.3	64.6	30.7	33.9
Peat : perlite : soil	6.1	0.15	0.46	10.2	56.1	12.3	43.8
Significance	*	**	***	***	*	**	*

[z]Porosity measurements determined using 14-cm columns of growing media.
[*,**,***]Significant at P = 0.05, 0.01, or 0.001, respectively, by t tests. Five replications per medium.

Table 2. Influence of growing medium and fertilization regime on growth and essential oil content of *Rosmarinus officinalis.*

	Plant characteristic[z]		
Variable	Ht (cm)	Fresh wt (g)	Essential oil content (% ± SE)
Fertilization regime[y]			
LF weekly	39.0 a[y]	74.7 a	2.50 ± 0.08
LF weekly + CRF, 4.5 g/pot	37.1 a	70.1 a	2.36 ± 0.06
LF constant	38.9 a	68.5 a	2.31 ± 0.04
LF constant + CRF, 4.5 g/pot	33.0 b	50.2 b	2.31 ± 0.13
CRF, 9.0 g/pot	35.6 ab	73.1 a	2.24 ± 0.09
Growing medium			
Peat : perlite	38.2 a	71.5 a	2.27 ± 0.07
Peat : perlite : soil	35.5 b	63.6 a	2.41 ± 0.03
Significance			
Fertilization (F)	**	**	...
Growing medium (M)	*	NS	...
F × G	NS	NS	...

[z]Mean separation within main effects within columns by Duncan's multiple range test, P = 0.05. None of the variables significantly affected dry weight.
[y]LF = constant and weekly fertilization using 20N-4.3P-16.7K as a liquid feed at 150 mg N/liter. CRF = 12N-5.2P-12.5K controlled-release fertilizer applied to the media at the start of experiments.
[NS,*,**]Not significant or significant at P = 0.05 or 0.01, respectively.

growth of potted rosemary. The specific cause of growth suppression was not determined, but could have been due in part to high salinity or nutrient imbalance.

Many container-grown ornamental crops exhibit enhanced growth and increased plant quality in response to LF and CRF combined, compared to exclusive use of LF or CRF (Maynard and Lorenz, 1979), In our experiment, there were no significant differences in growth between CRF alone at 9.0 g/pot, weekly LF plus CRF at 50% of the recommended rate (4.5 g/pot), or LF applied weekly or at every watering (Table 2).

Plants grown in the soil-based mix were significantly shorter than plants grown in the soilless mix (Table 2). In addition, shoot fresh and dry weight tended to be lower among plants grown in the soil-based mix relative to plants grown in the soilless mix, but the difference was not significant. Bell and Coorts (1979) obtained similar results for lemon balm, peppermint, and sage produced in soilless and soil-based media.

Plants grown in the soilless mix required more frequent irrigations than those in the soil-based mix (data not shown). The need for a higher frequency of irrigation for the soilless medium likely was due to its lower water-holding capacity (Table 1). Lower water-holding capacity in the soilless mix was probably caused by higher levels of noncapillary pore space due to the greater proportion of perlite in the medium. According to Bailey (1927), rosemary is common on calcareous hillsides in southern France and thrives on well-drained soils. Reduced water-holding capacity and increased porosity may have been responsible for the slight enhancement of growth obtained in the soilless mix (Table 2).

Essential oil content was highest in plants receiving the lowest rate of fertilization, i.e., weekly LF (Table 2). These results suggest that high rates of fertilization suppress essential oil biosynthesis in rosemary. Yield of essential oil was higher in plants grown in the soil-based growing medium than in those grown in the soilless medium (Table 2). Fertilization practices, however, exerted a greater influence on essential oil content than growing media.

This study indicates that container-grown rosemary can be produced using low rates of fertilization, i.e., with 12N-5.2P-12.5K CRF as the sole source of fertilizer or with 20N-4.3P-16.7K LF once each week at 150 mg N/liter (Table 2). These two fertilizer regimes will result in plants that are similar in size or larger than plants grown at higher levels of fertilization, and they will reduce the potential for groundwater pollution arising from excessive fertilization. Both soilless and soil-based growing media are suitable for production of potted rosemary when fertilization and irrigation practices are controlled.

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